POWER PLANT ENGINEERING

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Power Plant at San Francisco Hospital

OIL BURNING PLANT SUPPLYING LIGHT AND POWER TO LARGE MODERN MUNICIPAL HOSPITAL. BY CHARLES W. GEIGER

THE SAN FRANCISCO HOSPITAL is maintained by the City and County of San Francisco for the treatment of its sick poor. The main group consists of ten buildings, costing $3,500,000, and has accommodations for 1000 patients. The equipment of the hospital has been given much attention, and the standard of the hospital is such as to entitle it to be ranked as one of the leading hospitals in America.

The power plant consists of four 250-hp. water-tube boilers, carrying 175 to 180 lb. steam pressure, which are fired by crude oil. The oil is heated to a temperature of 270 deg. F. under a pressure of 130 lb. This system is described in detail in the article entitled "Fuel Oil" on another page of this issue.

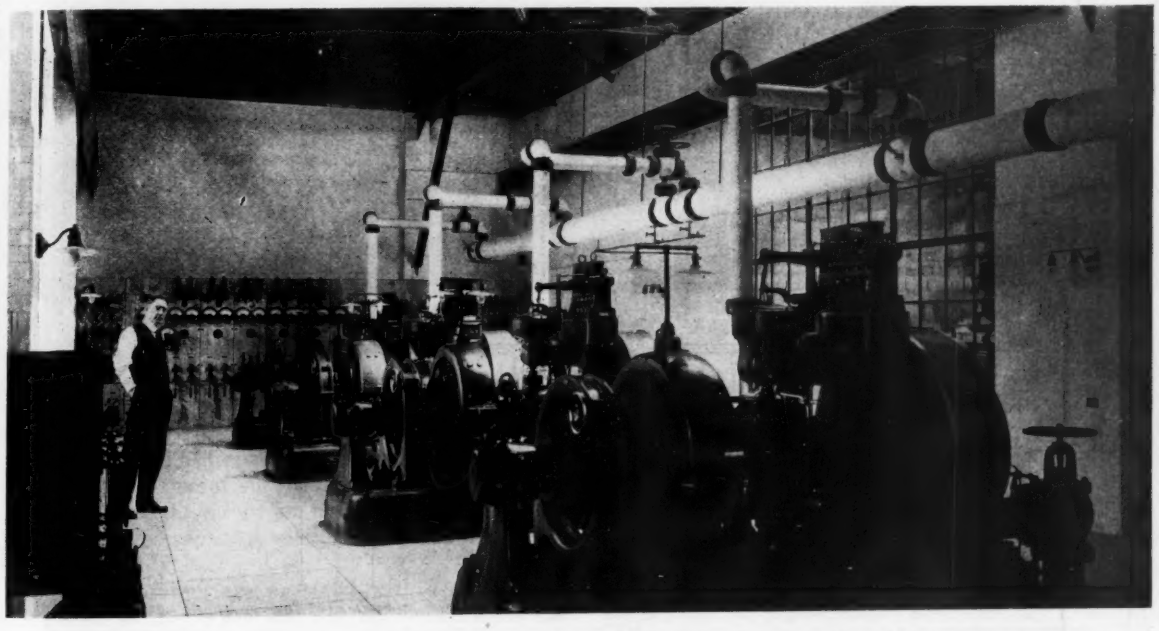


FIG. 1. GENERAL VIEW OF TURBINE ROOM, SHOWING MAIN SWITCHBOARD AT FURTHER END

The power plant is situated in the center of the hospital group (at the left of Fig. 3), so as to give equal distribution and minimum length of steam mains, etc., and supplies all electric power and steam used throughout the buildings.

Because of the fact that the hospital group is completely isolated from all outside sources of power, great precautions were taken to insure the efficient operation of the power plant and the generating equipment at all times. The equipment is housed in a reinforced concrete steel building with an extra heavy steel frame. It is finished on both the inside and outside with brick. The chimney is of reinforced concrete and is 150 ft. in height.

The electric generating plant consists of four 125-kw. turbo-generating units running at 2400 r.p.m. The generators are of the three-wire type, delivering current at 125 v. for lighting and 250 v. for power. The main switchboard is also located in the room with the generators and distributes both light and power to all of the buildings through individual feeders to each. The switchboard consists of five generator panels, namely, one main power panel, one paralleling panel, three lighting panels. Each building has a main switch-

board for light and power. There are 138 electric motors operated throughout the buildings, ranging from ⅛ to 35 hp.

All steam, hot and cold water, steam return, gas, electric and other pipes are run in a system of tunnels connecting the power house with each building. All pipes in the horizontal and vertical directions are placed the water being heated to 140 deg. by the exhaust steam from the turbines and the auxiliaries.

Low-pressure steam from the turbine and pump exhaust is used for direct radiators in all wards and buildings, except in the receiving building, where the plenum system is used for the heating of the operating rooms and amphitheaters. The ventilation in the receiving

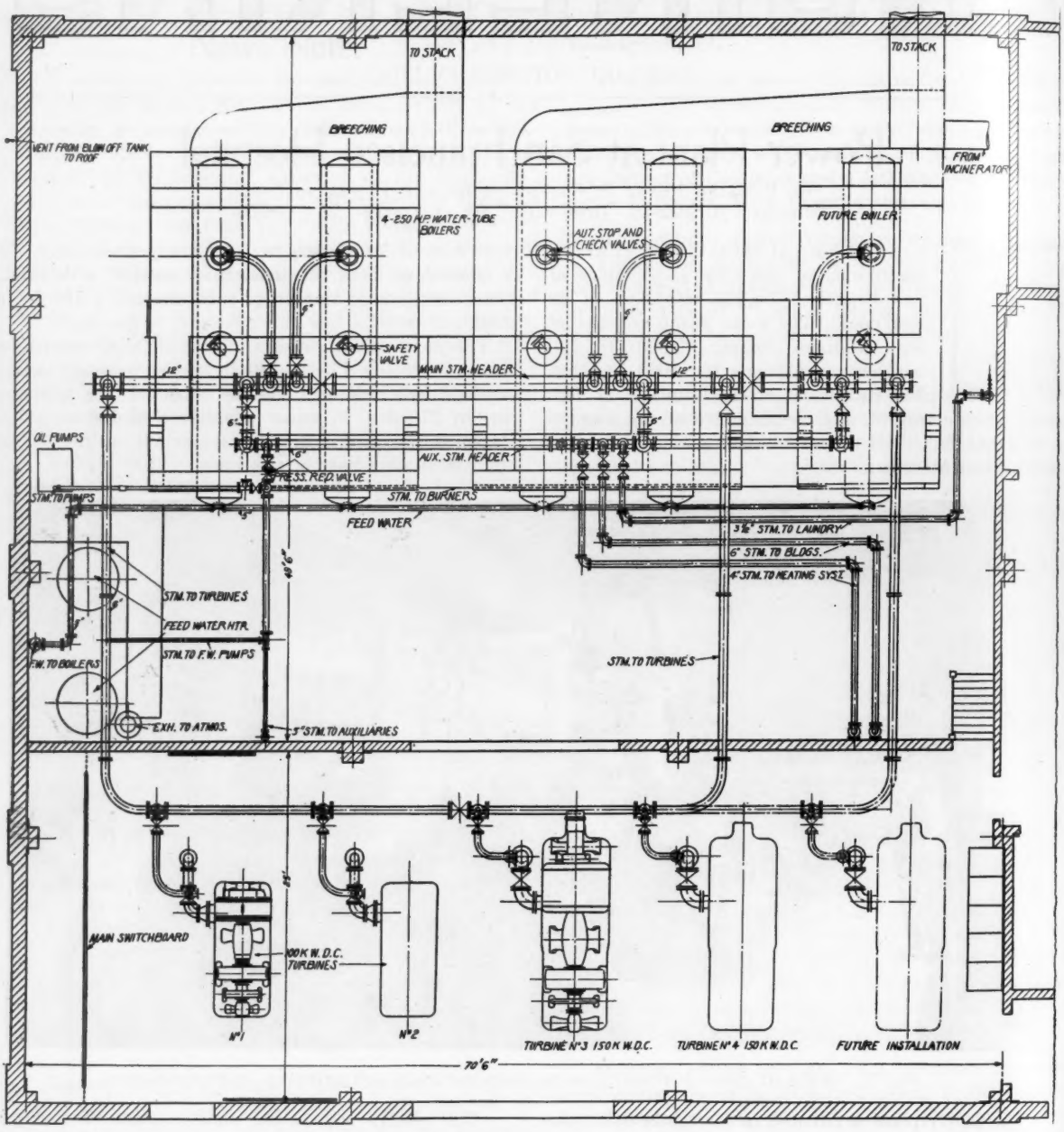


FIG. 2. PLAN OF TURBINE AND BOILER ROOMS

so as to be within easy reach in case of the necessity of repair. These tunnels are at least 8 ft. square. All pipes are placed at the top of the tunnel on I beams with rollers and expansion joints at every 100 ft. of pipe.

All pumps in the power plant are duplex and in duplicate, reducing the chance of a shut-down to the minimum. The hot water system is of forced circulation, building is controlled by a double mechanical system—one for the supply and one for the exhaust, the air being drawn in through an aperture 50 ft. above the ground, washed and distributed by fans, after proper heating, to the various operating rooms. The mechanical exhaust system of ventilation can be operated separately in different parts of the receiving building. There are 38,000

ft. of direct radiation installed in the buildings so far constructed.

The following pages are devoted to a more detailed description of the equipment.

There is a laundry located on the southerly side of the power plant, with which it is closely connected, in which a complete and very extensive plant is installed, all machinery being electrically operated. In addition to supplying steam for the steam turbines, boiler-room auxiliaries and heating system for the buildings, the boilers supply steam for the laundry.

Boilers and Piping

The turbine room is located on the ground floor of the power plant, and the boiler room in the basement with the boiler room auxiliaries under the ground floor. The boiler plant is operated under 175 to 180 lb. per sq. in. gage pressure, and 100 deg. F. superheat. There are four horizontal water-tube boilers of the straight tube type and are so arranged as to make two batteries of boilers. Each boiler has 2500 sq. ft. of effective heating surface. All parts of the boiler under pressure except tubes are constructed entirely of open hearth steel.

Each boiler is equipped with an integral forged steel superheater capable of superheating the steam approximately 100 deg. at the boiler nozzle when operating at or near the rated capacity, with crude oil and 50 per cent excess air supply.

The superheaters are provided with a flooding arrangement, so that when starting up, boiler water can be admitted into the superheater to prevent burning out. The superheaters are also designed with reference to ease of cleaning, so as to maintain the original superheat for which it was designed.

All steam power plant piping 1½ in. in diameter and under is butt welded and all over 1½ in. is lap welded. All lap welded pipe was tested at the factory to a hydrostatic pressure of 500 lb. and all butt welded 300 lb. All high-pressure wrought iron pipe, after being erected, was tested to 265 lb. hydrostatic pressure and 180 lb. working steam pressure.

All fittings and pipe 3 in. in diameter and over are flanged; all pipe and fittings under 3 in. are screwed. All piping ¾ in. and over have cast-iron flange unions for each length, so that any section of the pipe can be readily taken out without disturbing the balance.

All piping is supported overhead by 1-in. wrought-iron hangers. The main steam header is 12 in. in diameter and is anchored at the center by support from the steel boiler front frame. Expansion and contraction of the steam piping is compensated for by means of lateral tees. All pipes in trenches are supported on short pieces of 1½-in. pipe laid crosswise on the bottom of the trench. The main steam line leading to the various buildings is 16 in. in diameter. This is said to be the largest heating line in San Francisco.

All high-pressure fittings for 3 in. in diameter and above are ferro-steel flanged fittings suitable for a steam working pressure of 250 lb.; low-pressure fittings for 3-in. diameter and under are of screwed heavy beaded malleable iron pattern.

Reducing valves are installed to reduce from working pressure to pressures as follows:

FIG. 3. GENERAL VIEW OF THE HOSPITAL. POWER PLANT AT THE LEFT

Steam supply to the laundry and buildings reduced to 100 lb. or lower.

Steam supply to the heating system reduced to 100 lb. at main steam header, and at the heating main to atmospheric pressure or lower.

Steam supply to coil in hot water supply tank to 50 lb. per sq. in. or lower. Steam supply to domestic water heaters to 80 lb. or lower.

All high-pressure returns and drips are returned by traps from the high-pressure steam supply to buildings, heating system, laundry, etc., and are collected into a manifold back of the feed-water heaters, and thence discharged to the heaters. All low-pressure returns and drips that cannot be returned by gravity to the heaters are connected to the vacuum pumps through vacuum valves and then returned to the heaters.

Heat Insulation

All live steam pipes of 4 in. and over are covered with 85 per cent magnesia broken joint method 2 in. thick. All live steam pipes 2 in. to 4 in. are covered with straight joint method 1½ in. thick. All other

live steam pipes and all exhaust pipes, also all drips and return lines are covered with standard 85 per cent magnesia. All covering has a canvas jacket painted two coats of anti-flame paint. All sectional covering in the boiler room is supplied with black varnished bands put on every 18 in.

After all covering for piping had received the final coat of anti-flame paint, arrows were painted on the pipe covering at suitable distances apart, in the direction of the flow of the steam, water, etc., and so placed that they can be readily seen from the boiler and turbine floors in colors as follows: Red arrow indicates steam, black arrow indicates exhaust steam and drips, blue arrow indicates cold water, and green indicates hot water and returns. A plan of the piping is given in Fig. 2, while Figs. 4, 5 and 8 give various elevations.

The outside of all boiler casings and boiler fronts and all exposed parts of the boilers were primed with two coats of priming paint before being installed and

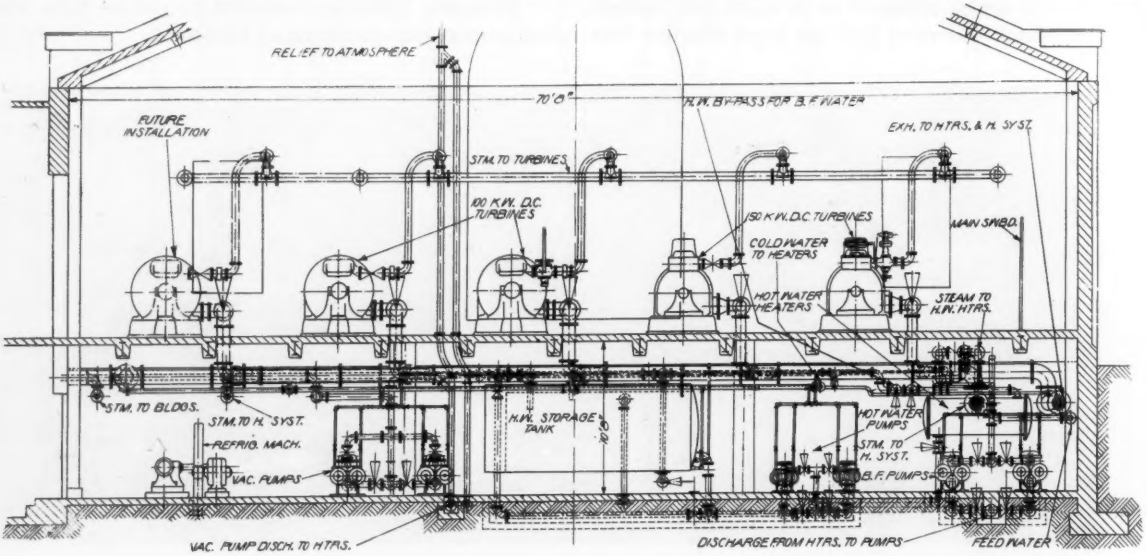


FIG. 4. SECTION THROUGH TURBINE ROOM SHOWING AUXILIARIES IN BASEMENT

work entirely independent of the brick work, thus being allowed to expand and contract without influencing the setting.

The boilers are set two in one battery, with room for a third battery, should that ever be necessary. The side wall of the battery and single is laid with hollow air space 2 in. wide which is filled with non-coducting material. All fire brick were dipped in clay batter and laid by rubbing them into place, so as completely to fill all joints and make them as thin as possible.

All red brick were laid in a mortar consisting of one part cement, two parts lime and six parts sand. Exposed portions of the boiler drums were covered with one coat of non-conducting covering 1½ in. thick, consisting of 85 per cent magnesia. Covering on tops of the boiler drums is of sectional block form. An elevation of one battery of boilers is given in Fig. 8.

Valves on the main and auxiliary steam header and feed-water heaters are made easily accessible by means of a runway supported from roof trusses. A ladder has been built on the side of the first battery of boilers from the top of the platform to the floor. The runway is 18 in. wide and has a checkered steel floor plate, also a 1-in. hand rail.

after being erected in place were painted with two more coats and varnished. All direct acting steam pumps and exposed parts on auxiliary machinery were painted with two coats of priming paint before being installed, and after being installed they were painted with two additional coats and varnished.

Details of Boilers

All boiler drums were riveted together with double riveted butt strap joints for longitudinal seams. All rivet holes were punched 3/16 in. smaller than the diameter of the rivets used and reamed out to full size after the sheets were rolled and assembled with their butt straps. The drum heads are of wrought steel throughout and contain a manhole 11 in. by 15 in.

Boiler tubes are 3½ in. in diameter, number 9 gage, and constructed of hot seamless drawn steel tubing. Each boiler is provided with a mud drum made entirely of forged steel and so designed and located as to form a receptacle for scale forming matter and is easy of access for blowing off, etc.

Boilers are supported on a structural steel frame-

There are rectangular breechings connecting the boilers to the openings in the stack. The breechings have 25 per cent larger area than the area of the stack. Breechings are made of 3/16-in. steel riveted with ⅜-in. rivets, with a 3-in. pitch; 18 by 24-in. cleaning doors are placed in the breeching.

Pipe trenches are of concrete of 4-in. sides and walls, and are water tight on the bottoms and sides, and to a pitch of 1/16 in. per foot toward the floor drain for drainage of trench. The tops are made of heavy cast iron, diamond pattern covering plates, with lifting holes, making lap joints with each other and sides of the trenches. The top of the plates are flush with the floor and are 4 ft. in length.

There are four oil tanks for storing the lubricating and lamp oil, with connections through which they may be filled from the sidewalk. These tanks are made of

galvanized steel No. 12 B. W. G. thick, each fitted with gage glass, manhole and cover near the top. A copper drain pan with a grating is fitted to the front of the tanks to catch all drains. There is one tank for engine oil having a capacity of 50 gal., one for cylinder oil with 25 gal. capacity, one for lard oil holding 25 gal., and one with a capacity of 25 gal. for coal oil. In addition to the fuel oil tank, with a capacity for 12,000 gal. of crude oil, there are four 1500-gal. tanks for supplying oil to the kitchens, each tank having one compressed air and oil pump electrically operated.

Boiler Room Auxiliaries

There are two horizontal duplex steam driven direct acting piston pattern boiler feed pumps, each 10 by 7 by 10 in. Each pump is provided with a ½-pint brass bodied sight feed lubricator and a brass bodied hand adjustable water safety relief valve, placed on the discharge of each pump so as to prevent an excessive pressure from accumulating in the pump chamber. It may be interesting to note that it has not been necessary to use lubricating oil on any of the auxiliaries. There is a cold water connection to the suction side of one of the feed water pumps, and a 1½-in. hose bibb on the discharge side for washing out the boilers. These pumps are designed for a working pressure of 180 lb. and were tested to a cold water pressure of 400 lb.

There are two vertical heaters and purifiers of the open back pressure type, each having a capacity to heat and filter 52,500 lb. of water per hour, from 60 deg. F. to 204 deg. F. delivered to the boiler feed water pumps when under a pressure of 5 lb. The heaters are 45 in. in diameter by 10 ft. in length and have a heating chamber with trays securely fastened in a nest independent of the shell; two filtering chambers, each 12 in. deep. A sediment chamber with flow off at its base, cast-iron hinged doors to all chambers for inspection and cleaning, a pump governor attached to each heater to control the steam supply to the feed-water pumps, is operated by a copper non-collapsing float, and heater mounted on cast-iron legs.

There are two horizontal duplex steam driven, direct acting, piston pattern hot water pumps that circulate hot water throughout the buildings. This system is so arranged that hot water can be obtained instantly on opening the faucets in any part of the buildings. Each pump is 10 by 7 by 10 in. Each pump is equipped with a pump governor with a bypass. These pumps circulate hot water through the system at 140 deg. F. and at a constant maximum pressure in the system of 100 lb. The pumps are designed for a working pressure of 180 lb. steam and were tested to cold water pressure of 400 lb.

There are two horizontal water heaters for supplying hot water for domestic purposes, each heater having a capacity of heating 3000 gal. of water to 140 deg. F. when supplied with sufficient exhaust steam at atmospheric pressure. These heaters are constructed of cast iron and have removable heads secured by bolts. There are no pipe connections through the heads, permitting the heads to be removed without breaking any connections. The tube heads are of cast iron and are a part of the shell. The heating surface consists of straight brass tubes. Each heater is equipped with automatic thermostatic control, to maintaing the temperature of the discharging water at the desired temperature. This thermostat consists of metallic tubes connecting to a balanced steam valve, the discharging water flowing through the tube, causing it to expand and then operate the balanced steam valve. Each heater is capable of withstanding a steam pressure of 180 lb.

The hot water supply storage tank is in the basement of the power plant. It is 6 ft. in diameter, 15 ft. long of ½-in. heads and ⅜-in. shell tested by hydrostatic presssure of 150 lb. This tank is provided with two syphon tank regulators, with a steam valve for holding the supply water in the tank at 140 deg. F. The tank is fitted with double coil of 2-in. seamless brass pipe of

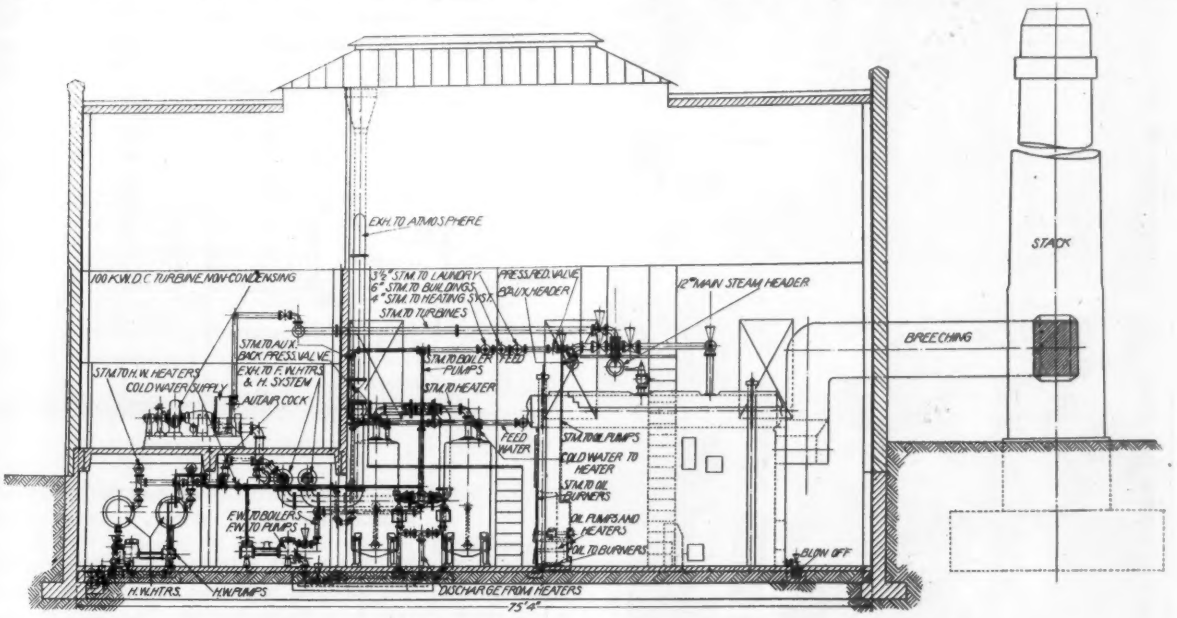


FIG. 5. SECTION THROUGH TURBINE AND BOILER ROOMS, SHOWING STEAM PIPING

iron pipe size of 125 sq. ft. of heating surface. The coils are fastened in position with galvanized iron hangers. An air chamber on the hot water supply to the building has been installed of the type similar to the one on the boiler-feed supply.

The hot water return storage tank is erected in the basement of the power plant. It is 5 ft. square and 13 ft. in length, and constructed of ¼-in. steel plate. An automatic balanced inlet valve is connected to the fresh water supply and operated by a float arranged to maintain a constant level in the tank. A cover for the tank consisting of ⅛-in. steel plates and angle irons is made in three sections, with all necessary holes for the piping.

There are two 10 by 14 by 18-in. simplex vacuum pumps connected to the return from the vacuum heating

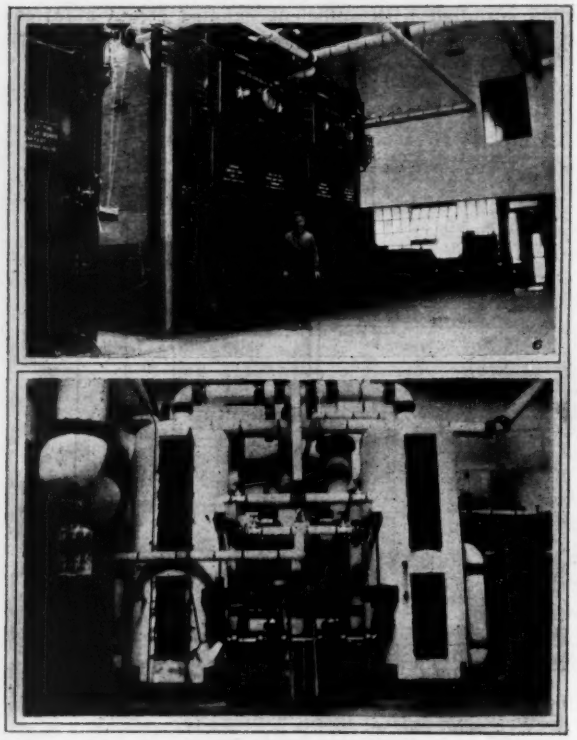


FIG. 6. ONE BATTERY OF BOILERS, AND THE WHOLE BOILER ROOM CREW—ONE FIREMAN

FIG. 7. WATER HEATERS AND PURIFIERS

system at the entrance to the boiler room on the boiler room side. Each pump has a capacity for returning all water of condensation from 45,000 sq. ft. of radiation operated on the two pipe vacuum system. These pumps are of the direct acting piston pattern, brass fitted throughout, having brass lined cylinders, brass valves, seat guards and pistons, phosphor bronze valve springs, phosphor bronze piston rods, and provided with a hand adjustable water safety relief valve.

Uses of Electric Power

The 138 electric motors installed throughout the buildings operate the elevators, laundry machinery, refrigerating and ice-making machines, vacuum cleaners, kitchen and bakery equipment, and numerous instruments in the dental department and laboratories.

In the main power plant there is a horizontal 20-ton ammonia direct expansion refrigerating machine, with brine system of circulation to the main refrigerators in the kitchen, butcher shop and main store-rooms, which is used for cold storage and ice making. This equipment is operated by a 220-v., 600 r.p.m. 35-hp. compound-wound motor, belt driven. The brine-circulating pump is of the horizontal duplex type, motor driven and direct connected.

There are three ice-making machines, one located in the basement of the power plant and operated by a 15-hp. motor; the other two are operated by a 5-hp. motor each.

The motors operating the automatic electric passenger elevators are of a type especially designed to meet the severe requirements of such elevator service.

All the machinery in the laundry is operated by direct-current 220-v. motors.

Each of the curb extractors is operated by 3-hp.

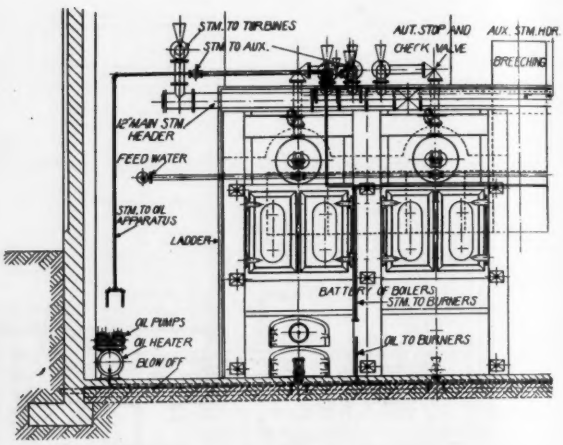


FIG. 8. ELEVATION OF ONE BATTERY OF BOILERS, SHOWING ARRANGEMENT OF PIPING

motors and each of the starch extractors by 1-hp. motors. The tumblers and washing machines are operated from a line shaft, driven by a 15-hp. motor. The body ironers and steam collar and cuff ironers are also operated from a line shaft, which is driven by a 7½ hp. motor. The remaining equipment in the laundry is operated by electric motors which are direct connected. On the switchboard in the laundry are mounted spade handle switches for the control of motors and lights.

The vacuum cleaner apparatuses are located in the basement of the various buildings and each is a complete system for the removal of dust and dirt from rugs, carpets, stairs, furniture and other furnishings throughout the buildings. The equipment is self contained belt driven by a 3-hp. motor, mounted on a common bed plate and installed in a manner so that any noise or vibration which might be communicated to the building is reduced to a minimum. The controllers for the vacuum cleaner motors are arranged for distant control.

Turbine Room

The walls of the turbine room, Fig. 1, are finished with white glazed tile to a height of 10 ft., which not only gives a very pleasing appearance but is very easy to keep clean. A track for a traveling crane extends the

entire length of the turbine room, but as yet no cranes have been installed. The room is so completely lighted by means of doors, windows and skylight, that no artificial light is necessary during the day. There are two large windows at each end of the room, and in the center there is a double door, which is 10 ft. in width and at least 18 ft. in height. This door is built almost entirely of wire glass. There are eight brackets carrying three lights each in the engine room, and each turbine is equipped with two lights connected directly to the generator which act as a telltale by showing whether the turbines are operating properly.

One generator is operated during the day, but during the peak at night two are operated. The load is about 400 amp. during the day but rises to about 550 during the peak at night. There are two 6-in. steam lines to the turbines, with a valve placed in the center of the line so that two of the turbines can be cut out.

In the turbine room there are installed a gage board and an instrument board of blue Vermont marble of ornamental design and carrying the following gages and clock:

One main steam pressure gage to register 250 lb.,

One pressure recording steam gage to register 250 lb.,

One combined vacuum and pressure gage to register 30 lb.,

One electric clock,

One pressure gage in hot water supply to building at the tank to register 150 lb.

Thermometers to register from 60 to 400 deg. F. located as follows:

One for indicating temperature of water entering the boiler feed-water heaters,

One for indicating temperature of steam in the heating system before entering the tunnel,

One for indicating the temperature of the water leaving the hot water storage tank,

One for temperature of water in return hot water storage tank,

One for boiler feed water supply to boiler after leaving the heaters,

One recording water meter on the supply to the power plant, near the supply to tank,

One thermometer and well in the main steam circuit in the turbine room,

One thermometer and well in the main steam header.

All the gages, thermometers and clock are brass bodied, nickel plated, with back connections and 8½-in. dial.

The entire plant is operated by one engineer and one fireman, working in 8-hr. periods.

The plant is under the charge of Chas. M. Long, who originally installed the equipment for Robert Dalziel Co., who did the engineering and contracting work.

The Building

There are some features in the construction of the plant that may be of interest. The basement floor of the power plant consists of 4-in. slab plain concrete with a 1-in. finish. For columns, footings, basement terrazzo and cement floors, slabs, piers, foundations and retaining walls and all walls over 8 in. in thickness the proportions of the concrete were one part cement and eight parts aggregate. For reinforced floors, and landing slabs, and interior staircases and walls under 8 in. in thickness the mixture was one part cement and six parts aggregate.

The face brick used are similar in color and texture to the brick used in the main group of buildings, and the exterior of the plant presents a very artistic appearance.

There are four terra cotta consoles supporting the wood brackets and hoods over the entrances, with a three-color polychrome finish.

All roofing for the power plant is five-ply felt, asphalt and gravel roof laid on concrete roof slabs. The concrete roof slabs were laid smooth and graded to carry water to the outlets. The slabs were then cleaned with wire brushes and brooms and thoroughly mopped and perfectly covered with a heavy coating of refined asphalt "D" grade of 40 to 50 penetration. The first ply of felt was laid with the seams lapped a good inch, and solidly mopped to the concrete roof slab. Over this first ply of flax felt were laid shingling fashion three plies of saturated felt, these being mopped with hot asphalt to the flax felt and then mopped with the same asphalt the entire width of the lap of each sheet. Over these three plies of saturated felt there was placed a

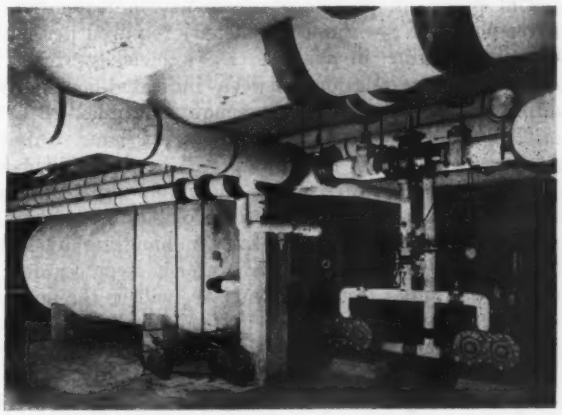


FIG. 9. HOT WATER TANKS AND PUMPS, AND OVERHEAD PIPING WITH ARROWS INDICATING DIRECTION OF FLOW

fourth ply of the same quality felt, laid as a cap sheet, lapping at the seams 1 in. and solidly mopped the full width of the under sheets with hot asphalt. Over this cap sheet there was spread a flowing coat of hot asphalt, into which was embedded gravel from ⅛ in. to ⅝ in.

The roof and sides of the tunnel connecting the power house and laundry building with the service building (in which were carried the pipes, conduits, etc.) were damp proofed by first coating the sides and top with hot asphalt as described on the roof. A three-ply layer of flax was then laid on the roof and one-ply layer on the sides.

There is a driveway leading to the power plant which was also damp proofed after which it was covered with a 2-in. cushion of dampened sand. This was then rolled, tamped and slightly pitched to center, on top of which was laid selected red vitrified brick. A hot asphalt was poured into the joints of the bricks after which they received a final grout of cement.

All windows and door sills, the steps and buttresses at the entrances, curbs for cast-iron ventilators, curbs

and copings for driveway and light areas all received a ½-in. cement plaster coating.

All skylights were formed of No. 24 gage galvanized iron. Back of all louvres there were placed screens formed of 1/16-in. copper wire of ⅝-in. mesh set in a galvanized iron frame formed of ½-in. rods. Glass used in the skylight consist of corrugated wire glass ¼ in. thick.

Computing Steam Required for Boiler Feed Pump

By H. C. Crawford

TO COMPUTE the steam required to supply a boiler-used:

sed:

$$(1) \qquad W_1 = \frac{BP \times W_3 \times W_2}{(857{,}000 \times E_1) - (BP \times W_3)}$$

Wherein, W_1 = water (or steam) required per hour to operate pump, in pounds. BP = boiler pressure, in pounds, per square inch. W_3 = specific steam consumption of pump, in pounds of steam per indicated-horsepower hour. W_2 = water (or steam) required per hour to operate engine, in pounds. E_1 = efficiency of steam pump, showing relation between indicated-horsepower output and actual or water-horsepower output.

The steam or water, W_1, required per hour to drive or operate the boiler feed pump will be determined by the load in horsepower which the pump pulls and by the number of pounds, W_3, of steam per indicated-horsepower-hour which the pump uses in handling its load. Then the product of the actual water-horsepower developed by the boiler-feed pump and W_3 will be the pounds of steam required per hour in feeding the boiler for the pump alone, at an efficiency of 100 per cent. Then, to obtain the pounds of steam per hour actually required to drive the feed pump, it will be necessary to divide this product by the mechanical efficiency of the pump, expressing these operations in a formula, thus:

$$(2) \qquad W_1 = \frac{W_3 \times \text{hp.}}{E_1} = \frac{W_3 \times \text{hp.}}{E_3}$$

Wherein, hp. = actual water-horsepower developed by the boiler feed pump for supplying the boiler with water.

Now the net water or hydraulic horsepower which the boiler feed pump must develop in feeding the boiler must equal the product of the total water pumped per minute times the head against which it is pumped, plus 33,000. Expressing this as a formula:

$$(3) \qquad \text{hp.} = \frac{(W_2 + W_1) \times 2.31 \times BP}{33{,}000 \times 60}$$

Wherein, W_2 = water (or steam) required per hour to operate the engine, in pounds; 2.31 = constant to change pounds per square inch into equivalent feet head.

Simplifying the foregoing equation:

$$(4) \qquad \text{hp.} = \frac{(W_2 + W_1) \times BP}{857{,}000}$$

Now substitute (4) in (2), thus:

$$(5) \qquad W_1 = \frac{W_3}{E_1} \times \frac{(W_2+W_1) \times BP}{857{,}000} = \frac{(W_2+W_1) \times BP \times W_3}{E_1 \times 857{,}000}$$

Now solving for W_1:

(6) $857{,}000 \times W_1 \times E_1 = (BP \times W_3 \times W_2) + (BP \times W_3 \times W_1)$

(7) $(857{,}000 \times W_1 \times E_1) - (BP \times W_3 \times W_1) = BP \times W_3 \times W_2$

(8) $W_1 (857{,}000 \times E_1) - (BP \times W_3) = BP \times W_3 \times W_2$

$$(9) \qquad W_1 = \frac{BP \times W_3 \times W_2}{(857{,}000 \times E_1) - (BP \times W_3)}$$

Example: What is the steam consumption of a boiler feed pump in a plant where the following conditions obtain? The boiler pressure is 150 lb. per sq. in. The specific steam consumption of the boiler feed pump is 100 lb. of steam per indicated-horsepower-hour. The engine develops 2131 hp. and its specific steam consumption is 30 lb. per horsepower-hour. The efficiency of the steam pump is 75 per cent. Solution: The water required by the engine per hour will be: $2131 \times 30 = 63{,}930$. Then substituting in the formula:

$$(10) \qquad W_1 = \frac{BP \times W_3 \times W_2}{(857{,}000 \times E_1) - (BP \times W_3)}$$

$$= \frac{150 \times 100 \times 63{,}930}{(857{,}000 \times 0.75) - (150 \times 100)}$$

$$= \frac{958{,}950{,}000}{642{,}750 - 15{,}000} = \frac{958{,}950{,}000}{627{,}750}$$

$$= 1527 \text{ lb. steam per hr.}$$

Hence, to operate the feed pump in this plant there would be required 1527 lb. of steam per hr.

If there are other steam-driven auxiliaries besides the boiler feed pump in the plant, their total steam consumption per hour are added to the total steam consumption per hour of the engine and this aggregate value is then substituted in the formula for W_2.

At a luncheon given in his honor on Sept. 22 at the Engineers' Club, New York, by members of the Society of Electrical Development, Edward N. Hurley was presented with an engrossed and illuminated parchment, giving expression to the appreciation felt by the members of the society for his work as chairman of the United States Shipping Board. The presentation was made by J. M. Wakeman, general manager of the society, who mentioned briefly Mr. Hurley's part in the "rapid construction of those vitally important ships."

Sitting on the cross-arm of a 60-ft. pole, a lineman removed his rubber gloves to roll a cigarette. Waving to some admiring children below, his hand touched a high-tension wire and he was hurled to the ground. The safety engineer still preaches that Heedlessness is Headlessness.

FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

Adaptation of Furnace to Fuel. Letter No. 19

SCARCELY a week passes without my being asked something about the proper kind of fuel for a given furnace, and I desire to comment a little more at length on this matter. It is really a continuance of the discussion in my letter on "Furnace Capacity."

It is always a question whether or not the chief consideration is adapting the furnace to the fuel or the fuel to the furnace. The present campaign for smokeless chimneys in the City of Chicago has brought this question to the front with pronounced emphasis.

With any given furnace the results obtainable by a change of fuel are quite noticeable and in many cases owners are paying a premium for "smokeless" coals rather than submit to the expense of a furnace alteration.

Smoke and inefficiency are largely produced by inadequate draft. Where the stack capacity is ample, it is usually possible to draw enough air into the furnace through the fuel bed or through specially prepared openings above the fire to take care of the volatile gases. In this case incomplete combustion problems seldom arise, except where the load exceeds the capacity of the furnace.

In the case of low draft, there is always a tendency to split hairs in the matter of the quality and size of the coal to be burned. It will be found that slack offers too much resistance and capacity cannot be maintained. Straight washed nut offers the least resistance of any coal, but as a rule it is hard on the grates and brickwork and contains the maximum of smoke-forming gases.

In the first place, we start with the assumption that enough steam must be generated to carry the load, and therefore that fuel which will produce the steam must be bought. If this happens to be a high grade smoky fuel, then it becomes incumbent upon the owner to adapt the furnace to the fuel. It resolves itself into a question of furnace capacity, and the length of flame travel and furnace volume must be increased the required amount. This is covered in my letter on furnace capacity. If, however, the draft is sufficient to burn the necessary amount of any kind of coal, then it is a problem of adapating the fuel to the furnace. Even in the State of Illinois it will be found that the coals from various mines differ in their smoke-forming qualities; and it would be proper to experiment until a coal is found which produces the best results. In most all cases, however, a combination of both fuel and furnace changes is desirable. If any coal will serve from a capacity standpoint, then where smoke and inefficiency are conspicuous that coal should be purchased which produces most favorable results.

At the same time, interior furnace changes will result in increasing the length of flame travel and consequent furnace capacity. The fundamental principle underlying smoke production, however, must never be forgotten. Enough air must be admitted to the furnace to satisfy the requirements of the fuel, and in hand-fired furnaces air over the fire is necessary. If this air can be pre-heated a moderate amount by utilizing heat that would otherwise go up the chimney, so much the better. It should be injected into the furnace, however, at sufficient velocity so as to produce a violent mixing effect with the gases already there.

In a perfectly homogeneous fuel bed of incandescent carbon only 7 lb. of air per pound of carbon burned can be forced through the fuel bed, the rest of the air required for combustion must enter the furnace through holes in the fires or through openings above the fire. The undesirability of holes in the fire, even for this purpose, need not be commented upon; so that there remains to be provided adequate air admission under intelligent control. Furnace changes which will admit of this will undoubtedly vastly improve combustion conditions. If some such arrangement can be combined with the other two suggestions, improvement in stack conditions will be material and immediate.

The problem is not so difficult theoretically, but in practice furnace extensions are frequently impossible. The furnace must therefore be increased not in actual volume, but in intensity of effect. In other words, what volume there is must be worked harder and this can be done by providing the right amount of air at the right time and in the right place. It is in fact a furnace change.

I cannot, within the space of this letter, attempt any details of how this should be worked out; but the experienced engineer will, by working along these fundamental lines, be able materially to improve his operating conditions.

Purification of Coal

CONCENTRATING TABLE METHOD AND RESULTS OBTAINED. BY B. J. ROBERTS

FOR the past 3 or 4 yr. several of the large coal operators, particularly those producing coal for the making of metallurgical coke, have realized the necessity for a machine which would be more economical in the washing of the smaller or finer sizes of coal; that is, that which will pass through a ½-in. perforation down to the finest dust. To ascertain the best method of doing this work, experiments were made on various types of concentrating tables.

In the table washing of coal, in order to keep the per ton cost of operation at a minimum, one of the prime requisites is large capacity. After taking into consideration the limitations imposed in transportation of the finished machine, as well as its operation when erected, a coal washing table was designed which is a development of an ore treating table, but with a deck 2 ft. longer and 2 ft. greater in width, with a corresponding increase in size and strength of all under-construction parts.

The table concentration of metalliferous ores in which advantage is taken of the difference in specific gravity of the various minerals, in order to make a separation, is so well known as to make it unnecessary to go into a complete description. The difference between the washing of coal by the table method and the table concentration of metalliferous ores is, that in the washing of coal, the pure coal, being of a lower specific gravity than the refuse or non-combustible, is removed from the table along what is ordinarily known in the treatment of metalliferous ores as the "tailing discharge edge," while the refuse is taken off over the end of the table, where the valuable constituents of the ores are ordinarily removed.

NECESSITY FOR WASHING COAL

THE OBJECT of the dressing or washing of coal can be classed under two general heads:

1. The removal of the inorganic sulphur in whatever form it may occur, either as pyrite or otherwise.
2. The elimination of sand, slate and bony coal.

Sulphur carried in the coal as pyrite is usually in the form of lenticular pieces, or in balls, and is readily freed from the coal by crushing; however, due to its greater specific gravity (pyrite Sp. Gr. 4.95 to 5.10; bituminous coal 1.14 to 1.40), it is easily separated by wet concentration or washing methods. Pyrite is sometimes found so thinly interleaved with the coal strata as to have the appearance of a "splotch of bronze paint" on the piece of coal. In this form, its removal is extremely difficult, except by very fine grinding, and even then these thin scales are so light as to be readily held in suspension by the water and carried over with the pure coal.

Sulphur is also found in the organic form in coal, probably in combination with carbon and hydrogen, and as such is not mechanically removable.

METHODS

WHILE the use of wet concentrating table methods for the separation of the valuable constituents of metalliferous ores has been known and practiced generally for more than 60 yr., yet the use of tables for the purification of coal is but comparatively recent. Previous to the year 1918 practically the only coal washing equipment in use was that of trough washers, cone washers, jigs and a very crude form of trough washer known as the bumping table. In all of these various methods the losses in the fine sizes of coal were extremely great. On account of the low prices of coal and the abundance of the supply, efforts have heretofore been made to obtain only the cream of the output. The quantity of recoverable combustible passing out to the waste piles is estimated at anywhere from 20 to 60 per cent of the total tonnage of the discarded material. In the southern Illinois fields today can be found whole farms covered anywhere from 2 to 5 ft. and sometimes to a greater depth with fine coal, mixed with refuse. This condition prevails in practically every coal mining camp.

It was not until after the extremely painful experiences in this country during the winter of 1917 and 1918, when, due to the shortage of fuel, it was found necessary on one occasion to close down every industry in the country for five days and also to stop operations completely for one day each week thereafter for several months, that the coal operators became vitally interested in the economies to be practiced in the saving of fuel values. Furthermore, the rapid advance in the price of coal has resulted in a demand on the part of the consumer for clean coal and has opened up the subject generally. The purification of coal by the use of concentrating tables has not been confined to the bituminous product alone, as experimental work on anthracite culm in eastern Pennsylvania has produced remarkable results.

PROCESS OF TABLE WASHING

IN THE table washing of coal, the operation is as follows:

The raw coal, mixed with about twice its weight of water, is delivered to the feed box in the upper corner at the head motion end of the deck. Water distributing boards are provided and attached to the same side of the deck as the feed box in order to obtain a nice adjustment in the distribution of water over the deck surface. The table is erected in a horizontal position and is practically level longitudinally; that is, along the line of its reciprocation. A slight side inclination at right angles to the line of reciprocation and which is adjustable in order to meet the changing conditions, permits the clean coal to be washed down over the long edge of the table into a trough or launder, through which it flows to its ultimate destination, while the action of the head motion in reciprocating the deck at approximately 275 times per minute, with a length of stroke of ¾ in., drives the sulphur and refuse, which stratifies next to the surface of the table deck, out and over, the short edge, or refuse end, of the table, where it is caught in launders and conveyed to the refuse dump. The wooden riffles on the surface of the table deck aid in collecting and guiding the refuse to its proper point

of discharge from the table and also prevent the finer particles from washing over with the clean coal.

The capacity of a coal washing table is variable, depending on the ease of separation of the refuse from the clean coal, and also on the purposes for which the washed coal will be used. For example, if the coal is intended for use under boilers or in pulverized coal plants, the requirements, with reference to the reduction of ash, will not be so stringent, necessitating less careful washing, with a correspondingly greater capacity per table; on the other hand, in the washing of coal for the making of metallurgical coke, the prime requisite is the reduction of sulphur to the lowest possible limit, making necessary greater care in the operation of the tables, with a corresponding reduction in capacity.

Maximum power requirements per table are about 1½ hp. The amount of water needed is approximately 470 gal. per ton of raw coal treated.

Coal washing tables are usually fed from storage bins by means of some positive arrangement, such as a screw feed conveyor, which will insure a steady, continuous flow of material. With such an arrangement, the table can be adjusted to a certain position and requires very little attention, except to see that there are no choke-ups of launders, water pipes, etc.; in fact, one good table man who thoroughly understands the work should be able to operate 50 of these tables as readily as one.

Dewatering

For the dewatering, drying and storage of coal after washing, various methods are being used, the most common being that of the dewatering drag conveyor, or perforated bucket elevator. The perforations in the bucket elevator type are usually about 1/16 in. in diameter. The excess water, amounting to 75 per cent of that used in washing the coal, is allowed to overflow the boot of the elevator or drag conveyor, from whence it goes to settling tanks of the Dorr continuous discharge type. The settled material, containing approximately 40 per cent moisture, is removed through an opening in the bottom of the tank and either thrown in with the coarse dewatered coal or sent to vacuum filters, where the moisture is further reduced to between 15 and 20 per cent. The overflow water from these settling tanks is pumped to water storage basins, from where it is returned for re-use on the tables.

The use of centrifugal dryers is another method being more or less generally adopted, although the objection to this is that the mesh of the screen plates must necessarily be so coarse that it allows of the escape of the finer material, which is, however, recovered in the settling tanks before mentioned.

At the Franklin washery of the Cambria Steel Co., Johnstown, Pa., are used what are known as dewatering pits built of concrete 30 by 30 by 16 ft. These pits have false bottoms made of wooden grates with 3/16-in. openings between the slats. The coal, as it comes from the washery, is sluiced into these pits, where the water is allowed to drain off through the false bottom or overflow around the edge of the tank. After the pit is full of coal, it is allowed to stand for a number of hours, in order to drain off the water remaining in the coal. This is a slow process and is wasteful of the finer coal.

Costs

On account of varying conditions, it is extremely difficult to get an idea of the cost of plant installations, but estimates have been made which run all the way from $3600 for single table installations for the treatment of screenings and refuse from the balance of the washery, to $300,000 for a 60-table plant of concrete steel construction. The per ton cost of operation, which includes interest on investment and plant depreciation, has been estimated from 10 to 12 cents per ton on a single table installation to as low as 3 to 5 cents per ton in a plant of 1000 tons daily capacity.

Results of Tests on Typical Coals

From a large number of tests made on Illinois coal containing sulphur extremely difficult of reduction, the following have been selected as representative:

TEST NO. 3

	Total Lb. Dry Wt.	Per Cent of Total Weight	Per Cent Ash	Per Cent Sulphur
Raw Coal	1593.00	100.00	12.50	3.12
Washed Coal	1394.50	87.54	6.09	2.36
Pyritic Iron Refuse (Sulphur)	8.50	.53	67.17	31.06
Refuse	190.00	11.93	48.63	6.87

TEST NO. 10

	Total Lb. Dry Wt.	Per Cent of Total Weight	Per Cent Ash	Per Cent Sulphur
Raw Coal	1017.00	100.00	17.62	3.54
Washed Coal	796.00	78.28	6.65	2.44
Refuse	174.50	17.15	53.15	9.09

From the foregoing figures it will be noted that the ash content of the washed coal is approximately the same in each case; in other words, it represents very closely the amount of fixed or non-removable refuse. A critical analysis of the work in these tests indicated that washing by the table method eliminated 90 per cent or more of the free or removable ash and sulphur content. In each of these tests the coal was washed at the rate of approximately 8½ tons per hour.

From tests run on Pennsylvania bituminous coals, the following have been selected:

WASHED COAL

Raw Coal Per Cent		Ash Per Cent		Sulphur Per Cent		Refuse Per Cent	
Ash	Sulphur	Ash	Reduction	Sulphur	Reduction	Ash	Sulphur
12.13	2.54	6.34	46.20	1.17	53.94	51.26	11.73
16.01	2.59	6.09	63.99	.90	65.25	55.86	8.48
10.52	1.85	5.46	48.17	.84	54.60	48.53	10.34
18.20	2.49	7.90	56.59	1.00	59.82	66.80	9.11
11.00	3.22	5.87	55.73	1.32	59.01	52.22	18.91

Advantages of Coal Washing

It might be well to enumerate here some of the advantages to be secured in the washing of coal.

1. Removes ash and sulphur matter, very objectionable in the making of metallurgical coke.

2. Reduces the losses by fire occasioned by spontaneous combustion in coal bins and coal piles. It is pretty generally admitted that the presence of sulphur in coal is, to a great extent, responsible for spontaneous combustion. The losses of one of the four big street and interurban railway companies of Indiana during the winter of 1917 and 1918 due to this cause alone was in the neighborhood of $15,000.

3. Reduces loss of combustible in ash. Two of the largest power companies in the country found that the ash from their steam plants contained from 40 to 50 per cent combustible. This combustible material was held to a great extent in combination with the clinker, from which it can be recovered only by fine crushing. By washing the coal previous to burning under the boilers, the iron pyrite, sand, limestone and other slag and clinker forming materials are removed, thus preventing them from combining and causing high loss of the combustible mentioned above. It also reduces the wear and tear on grates and other fire box appliances which come in contact with the burning coal.

4. Increases heat values.

5. Increases boiler efficiency.

6. Decreases transportation difficulties. Where coal is washed and treated at the mines, it will, of course, effect a considerable saving in transportation facilities, reducing the cost of transportation charges to the extent of the amount of freight usually paid on that amount of refuse.

7. Makes a marketable product from low grade screenings and that which at the present time is being lost in the refuse piles.

8. In the preparation of coal for pulverizing for use in plants where coal is burned in this manner, washing by the table process eliminates the hard materials which produce the greatest amount of wear on pulverizing machines. In a drying test made on washed coal where it was used in a pulverized fuel plant, it was found possible to reduce the moisture to 0.3 per cent, where their previous experience with unwashed coal had been that with great difficulty they were able to reduce it to 1 per cent.

Fuel Oil---II

TYPES OF BURNERS AND SETTINGS; DESCRIPTIONS OF PLANTS. BY CHARLES W. GEIGER

THE FIRST necessity in burning fuel oil economically is to atomize the oil finely into the firebox. Whether steam or air be used as the injecting agent, the oil must be broken by it into the finest possible spray, while at the same time the steam or air used must be reduced to the smallest possible quantity, both on account of the cost of steam or of compressed air, and on account of the waste of heat due to use of an excess of either. If the steam or air is dry or superheated and if the oil is heated, there will be a further saving, on account of the more rapid and perfect combustion.

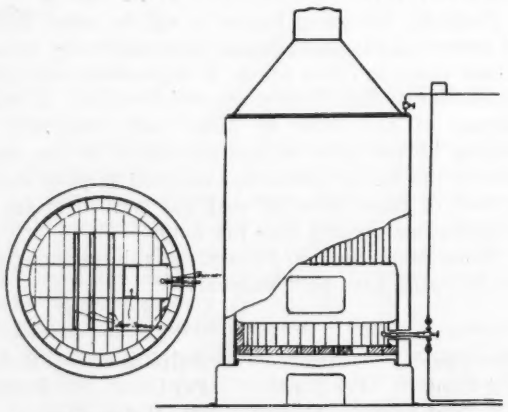


FIG. 4. VERTICAL MULTITUBULAR BOILER AS FITTED FOR OIL FIRING

To meet the necessity for perfect atomization and to minimize the quantity of steam or air required to do the work in the best manner, a great variety of burners, simple and complicated, have been invented. Many of these contrivances show great ingenuity.

Essentially, the oil burner is simply a spray, resembling very closely the ordinary steam jet ejector, a stream of steam or compressed air being depended on to break a smaller stream of oil into minute drops, and to throw these with some force from the nozzle of the burner. The first and most important point in the proper working of a burner is, as has already been noted, to break the oil into the finest possible drops, and this with the least possible consumption of the atomizing agent, whether steam or air. Other points of more or less importance are: that the burner should throw a flame of length and size proportionate to the size of the firebox, that the oil should be completely consumed without the formation of smoke or of carbon deposits, that the flame should be steady and not too noisy, that the burner should be readily regulated without tedious adjustment and readjustment of steam to oil, that the burner should be capable of carrying a small flame without breaking and of throwing a clear flame into a cold firebox, and finally that the burner proper should be durable, not readily burned if left to stand unused in place in a hot furnace, and that it should not be likely to become choked, either in use, from

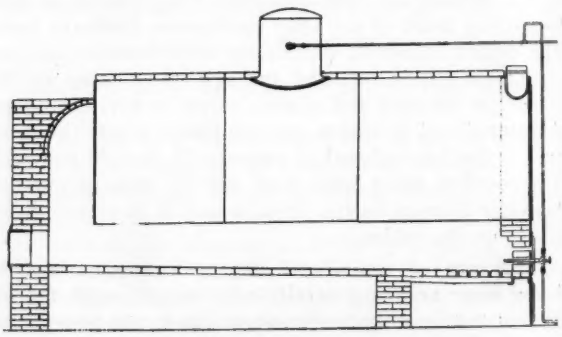


FIG. 5. FORM OF COMBUSTION CHAMBER USED IN CONNECTION WITH OIL FIRED HORIZONTAL RETURN-TUBULAR BOILER

dirt in the oil, or when turned off, from carbonization of oil remaining in the burner.

The proper construction of the firebox intended to burn oil is probably the most important matter connected with the installation of liquid fuel, as it is in the furnace that the proper combustion of the oil must take place. Figures 4 to 12 show methods of applying oil to various types of boilers.

The following pages will describe a number of oil burning plants in San Francisco recently visited by the writer.

Ferry Building Oil Burning Equipment

The power plant in the Ferry Building is perhaps one of the most interesting oil burning equipments in San Francisco. This plant was equipped with oil burners about 7 yr. ago, and as a result there has been a saving of 68 per cent in the cost of fuel over the cost of coal, which was used previous to the installation of the oil burner. During the 4 yr. of operation the only repairs made to the oil burning equipment was replacing a gasket.

The plant is equipped with two horizontal water-tube boilers of 100 hp. each. The boilers carry steam for

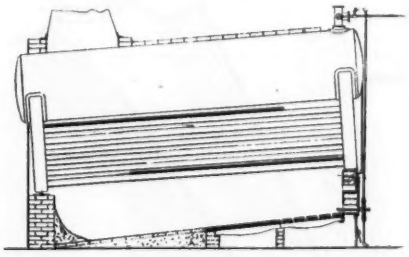


FIG. 6. INCLINED TUBE, INCLINED DRUM WATER TUBE BOILER ARRANGED FOR OIL FIRING

24 hr. daily for 8 mo. of each year, and for the remaining 4 mo. steam is carried 8 hr. daily. The plant furnishes steam heat for the entire Ferry building and the post office at the water front. There are 22,000 sq. ft. of radiators. A 4-in. pipe leads to the radiators in the Ferry building. An average of one barrel of crude oil is burned an hour during the winter months. The oil is stored in a tank having a capacity of 1890 gal. The top of the oil storage tank is 4 ft. below the floor of the engine room. A 2½-in. pipe leads to the oil heating and pumping equipment, and a 1-in. pipe leads from the pumping equipment to the burners. Figure 13 shows the heating and pumping equipment, consisting of an extra heavy semi-steel oil heater with a pedestal base, flanged head and special brackets to carry the drip pan and two duplex pumps; the body tapers off to form a self-contained base to fasten to the foundation, and also acts as a filter and settling chamber for all dirt, sand and water that precipitate from heating the oil, which can be blown off while the system is in use and under pressure, thus being self-cleaning.

The semi-steel drip pan is twice the capacity of the oil end of the pumps, which is an important item in overhauling the pumps.

The copper coil in the heater is of No. 10 gage and heats the oil from 60 to 150 deg. with the exhaust steam from the oil pumps and the addition of live steam, if needed, through the bypass. The coil is fitted to and through the flanged head of the heater and made tight by packed glands. The oil passes through the body of the heater around the steam coils, permitting the dirt and water to settle to the bottom, while the clean oil passes on to the burners from the top. By an arrange-

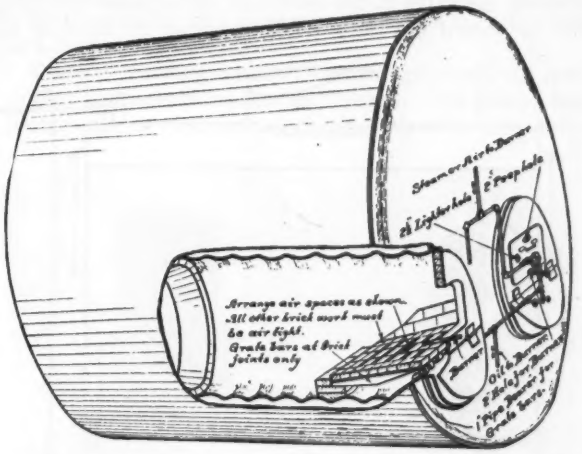


FIG. 7. SKELETON VIEW OF SCOTCH MARINE TYPE BOILER, SHOWING ARRANGEMENT OF AIR SPACES IN THE BRICKWORK

ment of valves and fittings either pump may be used, and an oil bypass allows the burner to continue in operation in case the heater should be out of commission or is being overhauled.

An oil relief valve is placed on the discharge line and fitted so as to allow any excess oil to return to the tank. There is also an automatic regulating speed and pressure pump governor, which insures uniform oil pressure to any number of burners, regardless of variations of the steam pressure. This governor is auto-

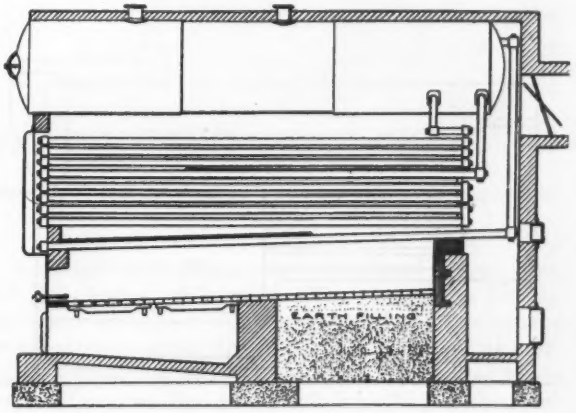


FIG. 8. HORIZONTAL TUBE WATER TUBE BOILER ARRANGED FOR BURNING OIL AND TANBARK

matically controlled by the discharge pressure from the pump. There are self-cleaning oil strainers on both the suction and discharge pipes. These strainers are shown in Fig. 14. The drawing to the left shows the operation of the strainer. The oil passes to the center, down the central tube, and is strained by passing through the perforated cone. The clean oil then passes up to the

exit, while the dirt settles to the bottom of the strainer to be blown out as desired. The drawing to the right shows how the strainer can be cleaned while the plant is running. First a bucket is placed under the blowout; then, by opening the bypass valve, the oil flows directly through the line as indicated by the arrows, when by opening the valve at the bottom of the strainer the dirt can be forced out with steam supplied by opening a

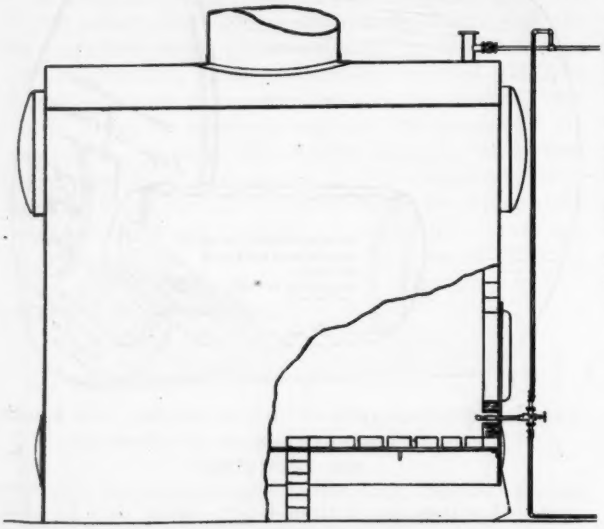


FIG. 9. ARRANGEMENT OF DONKEY BOILER FOR OIL FIRING

small valve at the side of the strainer. The flow or pressure of the oil is not changed while cleaning. The strainer can be cleaned out daily. If the oil is very dirty or the strainer hard to clean, while blowing out, the fireman shuts the blowout valve for a few seconds at a time and opens it quickly, the extra pressure and sudden release forcing the dirt out. If a leak in the

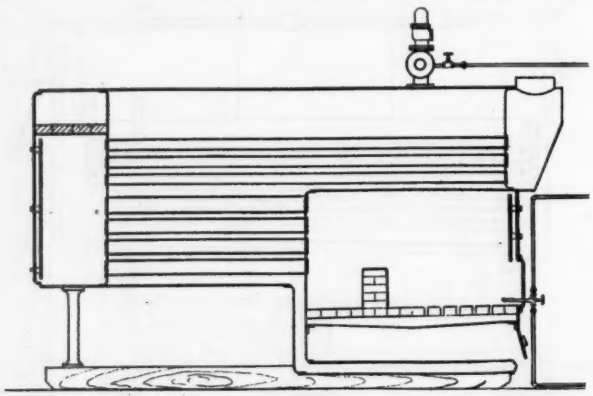


FIG. 10. ARRANGEMENT OF BAFFLING IN FIREBOX OF THE FIREBOX TYPE OF RETURN TUBULAR BOILER

suction causes difficulty in the operation of the pump, it can readily be located by closing the suction valve at the pump and opening the steam valve on the strainer. In this manner steam is forced into the suction line, and the leak will be indicated by the issuing steam. If the oil is thick and heavy, by closing the suction valve at the pump for a few minutes and opening the steam valve at the side of the strainer, the line can be cleared.

Compressed air is used for operating the oil pumps and for atomizing the oil in raising steam in a cold boiler. The air compressor, which is motor driven, was not installed primarily for this purpose, but was installed in the machine shop for operating air drills, etc.

One burner of the type shown in Figs. 5 and 6 is installed under each boiler. The oil is delivered to the burners by the oil pumps under a pressure of about 45 lb. and at a temperature of about 100 deg. F. Heating the oil lowers its viscosity, with the result that any suspended water more readily separates out. Oil is usually heated to a higher temperature in San Francisco plants, but the oil used in the Ferry building plant is very light, and it has been found that the best results are obtained by heating it to 100 deg. The exhaust steam from the oil pumps is ample to heat the oil to this temperature. Figure 15 shows the details of the burner. The oil and steam or air are passed through an inner and and outer tube and through specially arranger perforations to a mixing chamber, whence the mixture passes

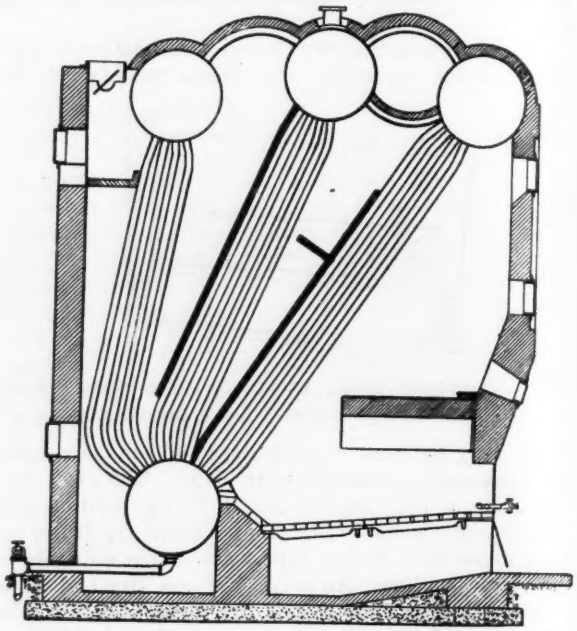


FIG. 11. ARRANGEMENT OF BRICKWORK FOR OIL FIRING FOUR DRUM TYPE WATER TUBE BOILER

through other perforations and channels to a head containing baffling plates, finally escaping through the openings. The various openings are not in line with one another, so that the stream is broken up. The oil tube contains a regulating spindle with a needle valve fitting the conical end of the tube, which itself serves as a valve to regulate the supply of oil. The oil enters the mixing chamber through radial perforations or inclined ones, the issuing streams in either case being broken up by opposing surfaces. The steam or air enters the mixing chamber through riflings, or passages, parallel to the axis of the tubes. To get the best results the mixer is set with point below the center, as shown in the diagram. The channels through which the mixture escapes to the burner tip are formed as slots in an enlargement at the end of the oil tube.

The method of starting up the burners is as follows

(see Fig. 16): The ashpit door and stack damper are opened, after which the blowout and bypass valves are opened full and needle valve opened one turn. Then the steam valve is opened until the steam blows dry. This drains steam line, heats up the burner, clears pipes, burner and strainer, proves control of the valves and clears the furnace of any gases, thus eliminating the possibility of an explosion. The oil pump is started up next, the excess oil being bypassed to the tank. The fireman now shuts the blowout and bypass valves tight and shuts the steam valve nearly off at the burner, lights an oily rag or waste and places it in front of, but a little to one side of the burner, closes the needle valve lightly, opens the oil valve full, and regulates the steam valve and needle valve to suit the fire wanted, also regulates the ash pan damper for the proper amount of air.

In shutting down, the fireman blows out the burner with steam, as follows: Shuts oil valve tight, opens steam and needle valves a full turn; next opens the bypass easy, but full, and lets steam blow through for half a minute; this cleans the burner out.

All steam and oil connections of the system are clear of pumps and heater head and bonnets, and are provided with bypasses to insure uninterrupted running of the plant in case of any part being refitted, changed or overhauled, without trouble or delay. The system is also fool-proof.

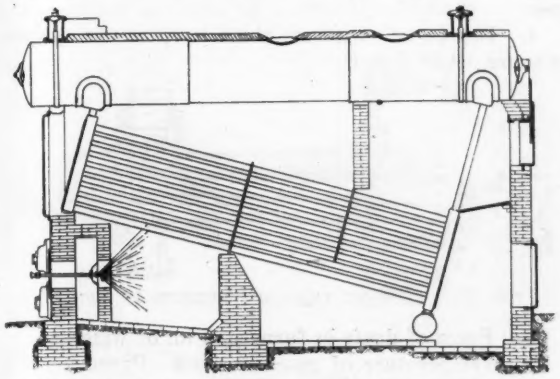


FIG. 12. METHOD OF ADAPTING THE VERTICALLY BAFFLED HORIZONTAL WATER TUBE BOILER TO OIL FIRING

Oil Burning in San Francisco Hospital

One of the most successful oil burning plants has been in operation for a number of years at the San Francisco Hospital. This plant supplies all electric power and steam used throughout the buildings. This hospital is an isolated institution, entirely cut off from all outside sources of electric current, and is dependent exclusively upon its own power plant for all electric current. This plant has been operating 24 hr. daily for the past 6 yr.

The power plant consists of four 250-hp. horizontal water-tube boilers, carrying from 175 to 180 lb. steam pressure, which are fired by oil burners. The cost of upkeep of these burners since their installation has been nil. The oil is heated to a temperature of 270 deg. under a pressure of 130 lb., which does away with the necessity of steam or air atomizing. The boilers are in batteries of two boilers each. Only one boiler of each set is used at a time. In case of accident to one of the boilers, a 12-in. valve on the main header line can be closed, thus cutting one-half the equipment off, reducing the chance of a shut-down to a minimum.

Fuel oil is stored in a 12,000-gal. steel tank, the top of which is placed 4 ft. below the floor of the fire room and surrounded with a brick wall for protection. Approximately 50 bbl. of fuel oil are used daily. A 2-in. pipe connects the fuel oil storage tank with the oil pumps and heater.

The oil burning system consists primarily of two duplex pumps, two heaters and burner. The pumps and heaters are in duplicate, so that in case of a breakdown or in case of overhauling, there will always be one pump and one heater in reserve. The dimensions of the pumps are as follows: 4½ by 2¾ by 4 in. These pumps are operated by steam direct from the boilers. The heaters are cylindrical shells of cast iron, with bolted heads designed so that the entire coil may be removed for cleaning or examination. All joints on the coils are made outside of the shell. The oil entering the first coil passes through a series of coils before reaching the burner. The oil is heated by live steam surrounding the coils.

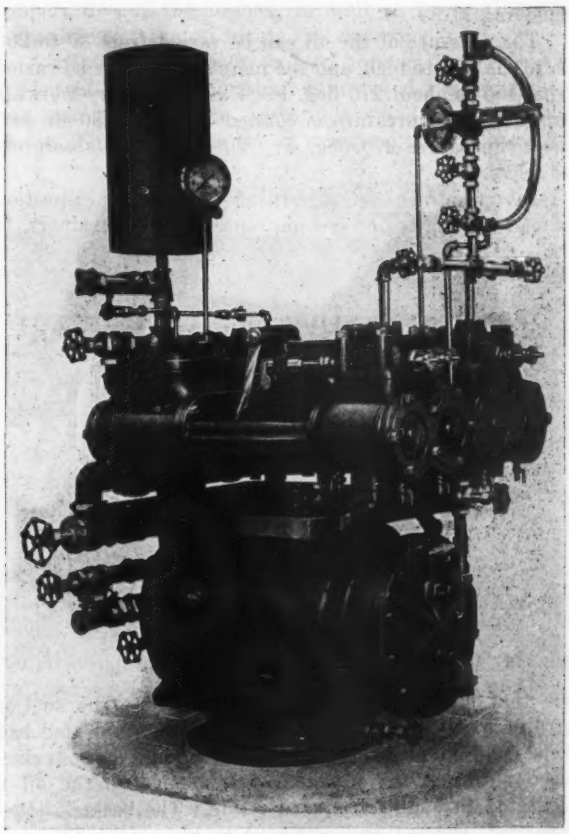


FIG. 13. TYPE OF HEATER USED IN THE FERRY BUILDING PLANT

The oil, after being heated to the proper temperature, is forced through the burner at the required pressure, the passages in the burner being such that the oil is thoroughly broken up before being discharged, so that it immediately volatilizes, and a perfect flame is obtained

as soon as the oil leaves the burner. The pressure under which the oil is forced through the burner and the size of the tip regulate to a nicety the exact amount of oil that can be burned. The quantity of oil can be varied to some extent by the pressure, and more by the size of the tip used in the burner.

The furnace front is so arranged that the burner passes through a pipe, on the end of which is a cone or deflector which can be adjusted by moving it in or out to secure the proper quantity of air just where it is needed. The front is extended, so that the whole length of the furnace is utilized, and the brickwork is so fitted that repairs and examinations can be made without removing it.

The pressure of the oil can be varied from 30 to 200 lb. to the square inch, and the temperature may be varied from 150 to about 270 deg. F. Under ordinary working conditions the pressure is carried at about 130 lb. and the temperature 270 deg. F. The system is absolutely noiseless.

In operating the oil-burning system, an inspection is made of the entire system, especially the strainers, to

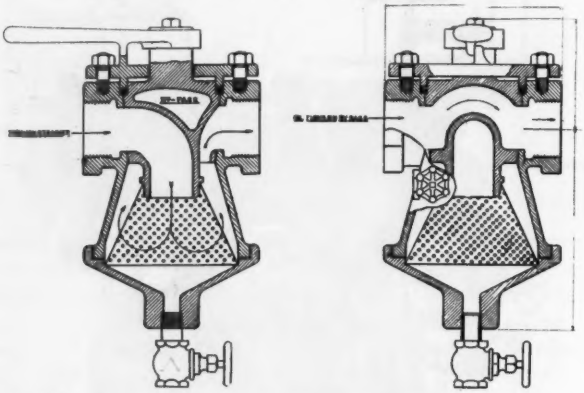


FIG. 14. STRAINERS USED IN THE FERRY BUILDING PLANT

see that baskets are clean and in place. The suction strainers are duplex, and are fitted with perforated baskets, held in place by the cover. Should one strainer need cleaning, the plug valve is opened so the oil is deflected through the opposite side. The basket is then removed, cleaned and returned to place without interfering with the operation of the system.

The discharge strainers are similar in construction to the suction strainers, with the exception of the plug valve. The bypass is arranged with separate valves. Valves are used on the discharge strainers in place of plug valve, to prevent any leakage owing to the high pressure.

With the burner valves closed and the valve at the end of the oil line open, the pump is started slowly to allow the oil to circulate back to the suction line. The operator then opens steam to the heater and drains it. He then closes the drain on the heater until it is just open enough to allow the condensed water to escape to the tank, and regulates the steam valve to keep the temperature steady. When the thermometer registers 180 to 200 deg., the operator closes the oil valve at the end of the line and opens the valve on the burner. The pressure gage on the line should register at least 30 lb. for starting, and with a lighted torch under the burner the oil ignites. This pressure is increased as the steam rises. The regulating cone is pushed as far in the furnace as possible and then gradually withdrawn until the edge clears the flame. This is then done with the second furnace. (Two furnaces are always kept burning while the remaining two are being overhauled.)

I noticed a letter from the U. S. Fuel Administration posted on the wall of the engine room, stating that after an inspection of the plant, the Fuel Administration could not make a single suggestion for its improvement, a statement which could not be made about any other plant in California. The engineer in charge of the plant, however, was not willing that this statement should be published.

Following is some interesting data from the test of the boilers made in May, 1912:

AVERAGE TEMPERATURES, PRESSURES, ETC.

1. Steam pressure, 171.23 lb. per sq. in.
2. Temperature of feed water entering boiler, 62 deg. F.
3. Temperature of steam leaving boiler (superheated), 441.5 deg. F. Superheater damper slightly open.
4. Degrees of superheat above temperature at boiler pressure, 64.58 deg. F.

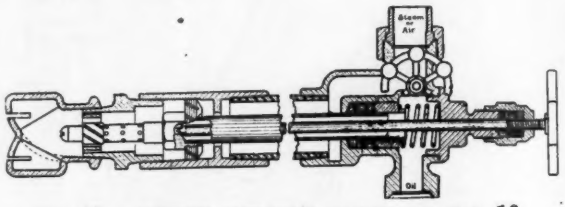


FIG. 15. SECTION THROUGH BURNER IN FIG. 16

5. Force of draft in furnace, 2 in. of water.
6. Temperature of gases in stack—Pyrometer registered 360 deg. F., but was found to have been broken on examination.
7. Temperature of fuel oil, 257 deg. F.
8. Pressure of fuel oil to burners, 122.4 lb. per sq. in.

TOTAL QUANTITIES

9. Duration of test, 4 hr.
10. Weight of oil as fired, 2366 lb.
11. Percentage of moisture in fuel oil, 1.00 per cent.
12. Weight of dry fuel oil delivered to burners, 2342 lb.
13. Gravity of fuel oil used in test, 16.5 deg. Baumé.
14. Specific gravity of fuel oil used in test, 0.95 at 17 deg. C.
15. Factor of correction for quality of steam, 1.036.
16. Factor of equivalent evaporation, 1.2083.
17. Total weight of water fed to boiler, 29,458 lb.
18. Equivalent water evaporated from and at 212 deg. F., 35,595 lb.
19. Equivalent water evaporated corrected for quality of steam, 30,518 lb.

19A. Same from and at 212 deg. F., 36,875 lb.

HOURLY QUANTITIES

20. Dry fuel oil consumed per hour (item 12 ÷ 4), 585.5 lb.

21. Equivalent water evaporated per hour corrected for quality of steam (item 19 ÷ 4), 7629.5 lb.

22. Equivalent evaporation from and at 212 deg. F. (item 18 ÷ 4), 8898.75 lb.

23. Same corrected for quality of steam (item 19A ÷ 4), 9218.75 lb.

24. Equivalent evaporation per hour from and at 212 deg. F. per square foot of heating surface (item 22 ÷ 2500), 3.55 lb.

HORSEPOWER

25. Horsepower developed (item 22 ÷ 34.5), 258.

26. Builder's rated horsepower, 250.

27. Percentage of builder's horsepower developed, 103.2 per cent.

ECONOMICAL RESULTS

28. Water evaporated under actual conditions per lb. of oil fired (item 17 ÷ item 10), 12.45 lb.

29. Equivalent evaporation from and at 212 deg. F. per lb. of oil as fired (item 18 ÷ item 10) (item 28 × 1.2083), 15.04 lb.

30. Equivalent evaporation from and at 212 deg. F. per lb. of dry oil (item 18 ÷ item 12), 15.02 lb.

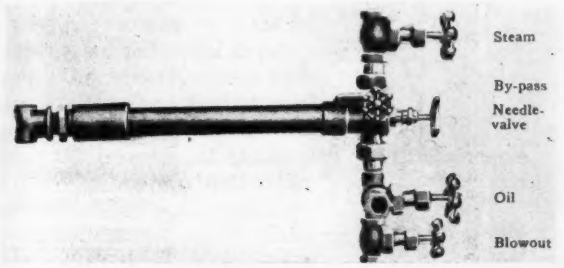


FIG. 16. TYPE OF BURNER INSTALLED IN THE FERRY BUILDING PLANT

31. Equivalent evaporation from and at 212 deg. F. per lb. of dry oil corrected for quality of steam (item 19A ÷ item 12) or (item 30 × 1.036), 15.74 lb.

PARTICULARS OF 250-HP. BOILER

Number of boilers in fire-room, 4.
Heating surface, one boiler, 2500 sq. ft.
Superheating surface, one boiler, Foster superheater.
Rated hp., one boiler, 250.
Working pressure, 180 lb.
Boiler tubes—number, 161; size and length, 3½ in. diam. by 16 ft.; gage, No. 9 B. W. G.
Steam drum, 48 in. diam.
Feed water connection, 2 in. diam.

REPORT ON SAMPLE OF FUEL OIL TAKEN DURING OFFICIAL BOILER TRIAL

Specific gravity, 0.9500 at 17 deg.
Baumé, 16.5 deg.
Water, 1.0 per cent (by distillation).
Estimated B.t.u. in oil used, 18.473.

Fuel Oil in Schools

Fuel oil is used very extensively in the heating systems of schools throughout California. The following is a description of the oil burning system in use in the Oriental School, San Francisco.

A revolving head or atomizer is installed in the center of the firebox and a circular firebox constructed of fire brick. The oil, on leaving the rotating head, is sufficiently broken up or atomized as to be readily ignited by a piece of lighted paper. The revolving head is also equipped with two sets of vanes, which supply currents of air, both below and above the oil film, of sufficient quantity to produce complete combustion.

Surmounting the revolving oil disk is a stationary top which is covered with a special high temperature cement. This top piece protects the head from the high temperature of the firebox, as well as preventing the carbonizing of the oil inside the revolving head.

A small electric motor is used to operate the revolving head. To the motor shaft is attached a worm reduction gear that in turn operates a small twin gear oil pump. For controlling the oil pressure, there is installed

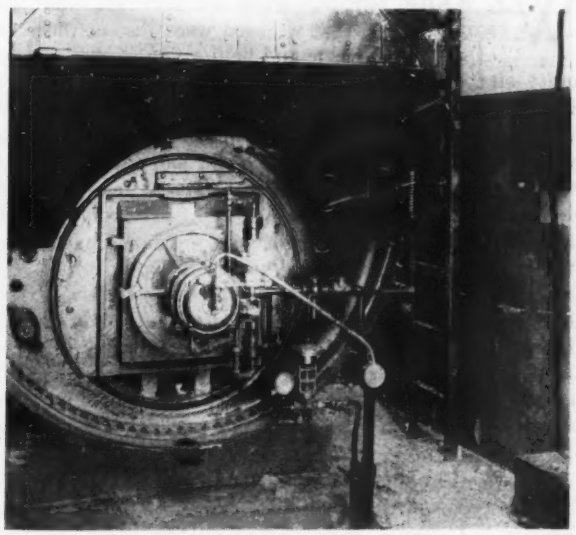


FIG. 17. TYPICAL INSTALLATION EMPLOYING A MECHANICAL ATOMIZING BURNER

a bypass or relief valve which establishes a back pressure and allows the excess oil to return back to the tank. The main supply pipe to the burner has a hand control shutoff valve and also an automatic valve that is actuated by the damper regulator of the boiler to maintain the desired pressure of steam.

As a safety precaution, the motor starting switch is so arranged that any interruption of the electric current causes the switch to release and stop the motor and oil pump. With this type of burner the oil is not heated.

Another type of rotary oil burner in which the oil is not heated (although the oil is warmed somewhat before it is introduced for consumption, because of the fact that the motor jacket is especially cast with a hollow frame so as to encase the motor completely and allow the fuel oil to pass constantly around the motor, which, in addition to warming the oil somewhat, also lengthens the life of the motor by keeping it cool at all times) has been installed in the San Francisco Juvenile Detention Home. In the system of oil burning employed here the oil is atomized in an open cup, lying horizontally, and

driven at 3450 r.p.m. and then forcing sufficient air at high velocity around the cup and in a direction away from the cup. This system not only introduces sufficient air for proper combustion, but also enough to direct the fire in the fire-box. Guide vanes are inserted in a nozzle surrounding the atomizer, which directs the air from a revolving motion to a straight path. The burner is operated by an electric motor which was referred to as slightly heating the oil. A typical installation of this type is shown in Fig. 17. A flexible connection to the motor is provided so that the door can be partly opened as soon as the fire is out, thus protecting the burner tip from the radiated heat from the furnace.

Pump Fails; Oil Transferred By Ejectors

By H. W. Rose

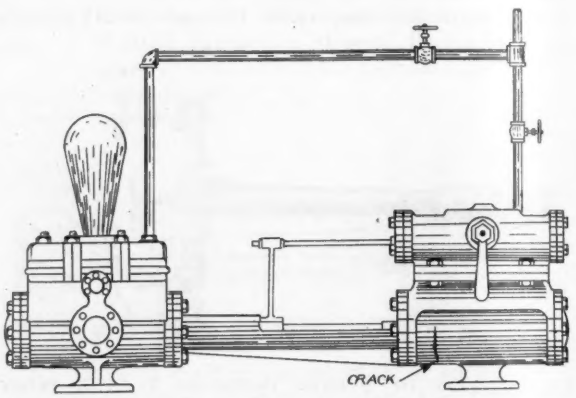
WE WERE burning crude oil for fuel, and the storage tanks that we used were just in the rear of the boiler house and held a two weeks' supply only, and located about 500 ft. farther off to the left was another storage tank which I had constructed into what I called my reserve fuel oil storage. In this case we were running night and day and had used up all of the oil in our oil tanks, with the exception of about a 4-hr. run, in going off duty. I told my assistant that the local freight, I had been informed, was bringing us two tank cars of fuel oil which was then about three days overdue, and that, as the train was due to arrive in an hour, it would not be necessary to transfer any of our reserve oil over to our running tanks. With that remark I turned the plant over to his tender mercies and care and proceeded homeward with the idea of settling down to enjoy a good mechanical article as soon as supper was over.

While at supper, however, I heard the whistle of the freight train and soon the roar of the engine drawing nearer and nearer, until she gradually slowed up and then stopped at the station one-half mile away. I drew a sigh of relief and said to myself, "He will soon have his oil now, and from the way the plant was running when I left it, a good night's run."

My supper was over and I had just indulged in two paragraphs of my interesting article when I was summoned to the plant. The messenger could not inform me as to the cause of my summons and as I hurried there I tried to speculate what the trouble could be, but could not think of a single probable cause. As I walked into the plant I was more at a loss than ever, for at a glance around me the general familiar hum of the various machines told my trained ear that everything was "jam up," as the boys say, until I saw my assistant coming toward me from the boiler room, and from his expression I read enough in an instant to know that not only something had happened, but something very serious.

Before I could think further he was at my side saying, "Chief, the local freight did not bring us any oil, and the oiler, in starting up the emergency transfer fuel oil pump, did not take time to work all of the condensed water out of the steam line before he put the pump to work and cracked the steam cylinder."

I knew in an instant that we were in a close jam, and to think of losing 4 to 6 hr. in a shut-down for the lack of fuel with 100 bbl. on hand seemed ridiculous. A hasty examination as to the damage told that temporary repairs were out of the question, as it was a real machine shop job. To transfer the oil by buckets or barrels would prevent the shut-down, but surplus help was not available; therefore that scheme was blocked. To replace the pump with another which was available would take too long with no more assistance than I had. My mind was working rapidly. I walked from the pump that I thought of installing back to this disabled transfer pump, which was located down at the reserve oil tank. It was placed there for the principal reason that it would push the oil better than it would pull it, as sometimes the oil we used would be very viscous and would have to be heated before the pump would pull it, and in a long suction line the oil would vaporize and the pump give considerable trouble. So it was changed and placed directly by the side of the tank, where it had no such lift, and under that arrangement it worked perfectly.



OIL PUMP, SHOWING LOCATION OF CRACK AND STEAM EJECTOR CONNECTION

It was rather a long distance to convey steam, but since the steam pipe was well insulated and the pump was never in reality used over 20 hr. in a month, I considered it a good arrangement under the surrounding conditions.

While standing by the disabled pump the idea of ejecting flashed through my mind, and at one glance the problem was solved, and for 2 hr. all hands and the cook were pipe fitters, and we saved our lives by just 35 min. Just above the throttle valve of the pump, as shown by the sketch, I made another connection into the top of the pump of the liquid discharge end into a hole which had been bored for the connection. The pump and suction line filled with oil and the steam valve then opened, and we had the prettiest working ejector you every saw.

Director General Hines states that the freight car situation is substantially more favorable than it was in recent years prior to the war. On Aug. 1, 1917, the total car surpluses reported throughout the country were 43,481 cars, whereas on Aug. 1, 1919, the total car surpluses were 107,900. The total number of unfilled car requisitions on Aug. 1, 1917, was 77,257, whereas the total number of unfilled car requisitions on Aug. 1, 1919, was only 19,271.

BENJAMIN G. LAMME

PIONEER IN ELECTRICAL DEVELOPMENTS WHO RECENTLY RECEIVED THE EDISON MEDAL OF THE A. I. E. E. HIS VIEW OF THE FUTURE FOR THE YOUNG ENGINEER. BY F. B. DAVIS

IT HAS been well said that though a great man build his lodge in the wilderness, the world will beat a pathway to his door. Long before Secretary Daniels introduced Benjamin G. Lamme to the rank and file of American people by appointing him on his Naval Board of civilian specialists, the engineering and electrical world had known him as one of the greatest men of his day, and already it had made a path to his abode a well-beaten highway.

Our day is one of material progress and industrial development. Our history makers have been inventors and promoters of industry. During untold centuries the progress of the race in these things was not unlike the pace of the snail, and then came the famous decade from 1830 to 1840, which Herzog calls "the cradle of the new epoch," in which Morse perfected the telegraph, Stevenson produced his locomotive, and the problem of ocean steamship navigation was first practically solved. In recent years, the most important developments have been in the domain of electricity. Its magic touch has quickened and transformed well nigh every phase of life. Many great names are associated with the rise of things electrical. One Benjamin deserves credit for discovering the first principles of one of nature's most potential secrets by trapping lightning with his kitestring, key and bottle; but to Benjamin Lamme, as much perhaps as to any other living man, is due the credit of harnessing the monster genie and making it the docile servant of mankind.

Benjamin G. Lamme was born on a farm near Springfield, Ohio. After a preparatory course in local country schools, he entered Ohio State University, from which he was graduated as mechanical engineer in 1888.

During his senior year in college, he spent considerable time in working up data and tables for the State Geologist of Ohio on the flow of natural gas through pipe lines of considerable length. It was on account of this experience that some months after graduation he applied, personally, for a position to George Westinghouse, then president of the Philadelphia Co., a natural gas concern, and cited his former work on this subject. He was taken into the engineering department of the Philadelphia Co. on the first of February, 1889, but in the following April made arrangements through the superintendent to enter the Westinghouse Electric Co., where he began in the test room.

Albert Schmid, then shop superintendent of the Westinghouse Co., also had charge of the drafting room, and later built up a very competent testing department. Mr. Lamme was virtually the first man in the test room to take up actual designing under Mr. Schmid's supervision, and in a period of less than 5 yr., as foreman of the testing department, had gathered around him a small but strong engineering force. Many of the company's early revolutionary developments were carried out in this way, under Mr. Lamme's personal supervision, and, in many cases, through his direct personal efforts.

In 1900 he was made assistant to chief engineer, serving in this capacity until 1903, when he received the appointment of chief engineer, which position he has held since. It was only a matter of a few years until the little plant where Mr. Lamme first started was outgrown. The company then moved to East Pittsburgh, where it now covers about 75 acres of floor space, employs 20,000 people, manufacturing everything from a sad iron to a locomotive, and delivers a carload of finished products every 15 min.

Mr. Lamme has ever been much of a pioneer. In the days before the well-known principles of building electrical machinery were fully established, he worked out his own designs, developed his own formulas and invented his own methods and systems. He has been a leader in the developing of alternating-current apparatus, including the induction motor, polyphase generators, rotary converters and single phase railway

equipment. He has also been a pioneer in the development of direct current apparatus for railway lighting and power work.

As an electrical engineer, Mr. Lamme is known the world over and is an exceedingly fertile inventor, having to his credit over 150 important patents covering electrical apparatus. His ability to analyze and grasp the facts of a great problem and his wonderful gift as an expert mathematician have placed him in the very front rank of engineers in this or any other country.

The recommendation of the appointment of Mr. Lamme was made to the Secretary of the Navy by the American Institute of Electrical Engineers, which appointment was made after a careful consideration of the entire membership of this organization, numbering over 10,000 and constituting one of the largest and most influential engineering societies in the world. In thus conferring this honor upon Mr. Lamme, the Institute has accorded to him the highest possible rank as an engineer and an inventor. His selection as one of the nation's Naval Consulting Board, as chairman of the Special Problems Committee, is an honor to his country as well as a recognition of his wonderful talent and judgment in large affairs where the interest of the country is involved.

To attempt to enumerate the achievements of Mr. Lamme in the engineering field would be beyond the scope of this article. His record and his prominent position with the Westinghouse Co. have fully established his position in the engineering field. Among the more prominent installations with which he has been identified may be mentioned the famous 5000-hp. revolving-field, Niagara Falls generators, installed in 1895. It is interesting to note in connection with the generators, which at that time were many times larger than any which had been built thus far, that the design was totally new and contained many radical departures from standard practice.

Probably the most important of all the designs and developments for which Mr. Lamme should receive a large amount of credit is the rotary converter, covering almost the entire field of the railway business. In the early days of the converter, beginning in 1893, this device was looked upon with a great deal of doubt, and it required no little persistency on the inventor's part to bring this particular apparatus favorably before the commercial world.

He has rendered some excellent service to the electrical art. When the A. I. E. E. standardization rules were under consideration for revision in 1912 and 1913, the most able men in the electrical profession in this country were consulted, and sought for some time a basic principle which would serve as a keynote in making a change so important as this in the recognized electrical standard of a nation. Many ideas had been submitted and rejected when Mr. Lamme advanced the conception that such a change should look into the future and cover the practice of the years ahead, rather than simply to recognize and give authority to the practice already developed. This idea at once cleared the air of controversies in a degree similar to those of the recent Peace Conference, and established the basis upon which the present revised rules stand—a monument to the ability of their framers.

Mr. Lamme is extremely interested in the training of young engineers and takes a particular delight in discovering young engineers in his organization gifted along the lines in which he himself has been successful and further placing them where they can make the most of their abilities.

In speaking of their future, Mr. Lamme recently said: "From the standpoint of development and inventions, the past looms large, but how about the present and the future? In looking over the past history of electrical engineering, the engineer may be inclined to think that the golden age of development and invention is past, and that the future contains no corresponding promise of new and startling things. But I do not agree that this is so. The pioneering period may be over, but the true development age possibly has just begun. The work is growing more difficult year by year, as our accumulation of knowledge grows. We are working ahead of our data, just as we did 20 to 30 yr. ago. Exactness and responsibility are required to a much greater degree than in the past, for our undertakings are greater in degree.

"But the young engineer need not be discouraged. The fact that the work is growing more difficult year by year should be, in itself, a source of encouragement. It has been my good fortune to see, from the inside, the electrical machinery development from the cut-and-try stage, through the intermediate steps, to the highly analytical methods of today, and my experience indicates that a higher grade of engineer is required now than ever before."

In commemoration of his singular and distinguished developments in the invention and development of electrical apparatus, the American Institute of Electrical Engineers has this year awarded Mr. Lamme the Edison Medal, the highest honor in the gift of the organization.

Engineering seems to be a family characteristic of the Lammes. His brother is a prominent electrical engineer upon the Pacific Coast, and his sister has also achieved real success in the same profession.

Such are some of the facts in the career of Benamin G. Lamme, a man who has climbed from between the handles of his father's plow to a position of world usefulness.

THE S. S. "ANOKA" of the American Hawaiian Steamship Co., which recently arrived in New York Harbor from Portland, Ore., ran through warm seas, the log book showing sea water temperature of 88 deg. day after day. This condition made it very difficult to keep the lubricating oil cool, especially as the boat was equipped with only one cooler. In fact, the oil entered the cooler at 124 deg. and came out but one degree lower. As a result of the use of this hot oil, the bearings of her turbines grew hotter and hotter, and at last, when they reached 164 deg., the chief engineer, Arthur Sheridan, decided that something had to be done. Casting around for a remedy, he conceived the novel idea of transforming his auxiliary condenser into an oil cooler, and this he proceeded to do with the aid of such tools and piping as he had on board. The success of this plan was complete, as the oil temperature was immediately reduced to 103 deg. and the bearings kept in proper condition. After reaching port, Chief Sheridan boiled out the condenser with soda and kerosene and was ready for port operation.—Scientific American.

An Analysis of Steam Trap Troubles

Lack of Care and Attention and Other Causes Which Lead to Trouble and Steam Waste. By L. E. Croup*

THERE is hardly another steam specialty about which so little is known, and which is so much abused as the steam trap. Traps are usually considered as a necessary evil, and, as a rule, very little care and attention are given to them. This should not be the case, for the importance of the trap, as regards its effect on proper metering and the large amount of steam that can be wasted by it, cannot be overlooked. Traps, when disregarded and forgotten, soon cause trouble and start to waste large amounts of steam. The three main causes of trouble makers are, (a) valves becoming worn, (b) dirt and scale clogging the traps, and (c) valve mechanism becoming loose. The following table was compiled from data contributed by four heating companies and covers a period of one year for most of the records.

Worn Valves

THE LARGEST number of troubles reported, being 31 per cent of the total, was caused by the valve being worn and the trap blowing steam. Some valves wear quicker than others, due to the kind of metals used, and sometimes, because of the construction of the trap, they are not tight and never were tight. The trouble usually starts when the valve becomes loose or clogged with dirt, allowing steam to be blown through the trap. When this starts, wiredrawing will tend to set in and conditions rapidly grow worse. Often vapor from the condensation makes one believe the trap is blowing steam. This can easily be determined if the trap has a water column, for if the column shows that the valve is water sealed, it is not blowing steam.

Dirt and scale clogging the valve mechanism together with the valve seat being filled with dirt caused approximately 25 per cent of the total number of troubles. Even on installations that have been in service 10 yr. or more, it has been found in several instances, that mud and scale are still being returned into the trap and then into the meter. The particular traps referred to have to be inspected and cleaned out several times a year. This causes much loss of time and delay in disconnecting and cleaning the trap which could be saved if strainers were used. Not enough emphasis can be made as to the necessity of using strainers on all installations, especially new ones.

Loose Valve Mechanism

THE NEXT largest source of trouble is loose valve mechanism. All parts of traps that are liable to wear, such as pins and bearings, should be made of metal which has the best resisting qualities for wearing, and should have the proper amount of reinforcing. Where screwed parts are used, some locking device should be provided, as they invariably work loose otherwise.

Included in miscellaneous causes were instances where a large number of floats were found leaking and this was no doubt due to faulty workmanship. Many traps were found to be sticking, due, no doubt, to dirt and scale clogging the valve mechanism. This only emphasizes still more that strainers should be used. The number having the valve seat worn was comparatively small, and was no doubt due to the same conditions as described under worn valves. Nearly all of the miscellaneous causes reported were due to air-bound traps. When a trap is air bound it has a tendency to retard the flow of condensation, or even stop it. This, of course, is not a fault of the trap and should not be charged against it. Air binding is liable to happen on any heating system. Automatic air vents should be used, and most traps are fitted with them by the manufacturer.

It is interesting to note the number of customers' complaints that were due to trap troubles. From the table it is seen that out of a total of 243 troubles, 218 caused complaints. Nearly all of these could no doubt have been prevented by more frequent inspections, thus giving the customer better service. This fact shows very clearly that it has been a fault of the heating companies practically to disregard the trap until attention is called to it by a complaint from the customer.

ANALYSIS OF STEAM TRAP TROUBLES

No. of Traps in service	3149
No. due to valve worn and blowing steam	75
Valve mechanism found loose	33
Float found leaking	25
Trap sticking (probably due to dirt)	32
Valve seat filled with dirt	26
Valve mechanism clogged with dirt	36
Number having seat worn	3
Miscellaneous causes	13
Total number of troubles	243
Ratio of Total Troubles to Total no. of traps in service in %	7.7
No. of customers' complaints due to Steam Trap Troubles	218

In conclusion of this subject, the following recommendations are submitted relative to the care and selection of traps:

1. In order to have proper meter operation and at the same time give the customers more satisfactory service, all steam traps should be overhauled at frequent intervals. A routine of trap inspections should be established, and if a trap is found blowing steam, it should be examined at once.

2. That the Rules and Regulations Committee include in their report an item making it necessary for customers to install strainers ahead of the traps, and that the customer be held responsible for keeping the strainer clean and in proper working order.

3. Steam traps should be selected with reference to their capacity for handling condensation at the pressures they are to operate under, as there are too many

*From a paper presented at the 1919 convention, National District Heating Association.

failures when based on the catalog rating of lineal feet of radiation, and on the size of the pipe connections. All traps should be rated by their capacity for discharging condensation at various pressures, and it is safe to say that it will not be very long until all the manufacturers will adopt this method. Traps should not be compared by prices only, for the highest priced trap may be the cheapest when compared on the basis of the cost per unit weight of condensation discharged, other conditions being the same. A steam trap should be selected large enough so that it will take care of the maximum demands at the minimum pressure which is liable to exist during coldest weather, for these conditions usually come at the same time.

Exhaust Steam Required for Feed Water Heating

By W. R. Davenport

In a non-condensing plant only about one-seventh or 14 per cent of the steam exhausted from the engine and auxiliaries can be utilized for feed-water heating. About 86 per cent of the exhaust steam is wasted. The feed water should be heated to 212 deg. F. It is impossible to heat it to a higher temperature (atmospheric pressure) without causing it to vaporize into steam. And, furthermore, it is a physical impossibility to heat the feed water to a temperature higher than that of the exhaust tseam which is used for heating. The temperature of this exhaust steam is always, at atmospheric pressure, 212 deg. F.

The exhaust from the engine and auxiliaries is practically all steam, although it does carry some moisture. This exhaust steam holds the same amount of heat as any steam at 212 deg. F. Now the latent heat in this steam, the heat which each pound of steam will give up in changing from steam at 212 deg. to water at 212 deg. is, as taken from a steam table, 970.4 B.t.u. But the heat required to raise the temperature of 1 lb. of water from 50 deg. F. (which is the average cold feed-water temperature) to 212 deg. F. is only: $212 - 50 = 162$ B.t.u. Therefore, the number of pounds of cold feed water which will be heated from 50 deg. to 212 deg. F. by 1 lb. of exhaust steam will be $970.4 \div 162 = 6.0$ lb. One pound of steam will, then, afford all of the heat that 6 lb. of feed water can, under the circumstances, absorb.

Now consider the proportion of the total steam generated which is useful in feed water heating. For each 6 lb. of cold water, at 50 deg. F. as above described, which is pumped into the boiler, 1 lb. of water condensed from exhaust steam is pumped in with it. (This assumes that an open feed-water heater is used.) This gives a total of 7 lb. of hot feed water pumped into the boiler for each pound of exhaust steam used. Thus only about 1/7 or 14 per cent of the total water pumped into the boiler—1/7 of the steam generated but finally exhausted through the engine and auxiliaries—can be effective for feed water heating. The remainder, or 86 per cent, of the exhaust steam is wasted—unless it is employed for heating or some similar useful non-power generation purpose.

Obviously the amount of exhaust steam of such a non-condensing plant should be maintained at a minimum. Thus the auxiliaries—boiler feed pumps and the like—should be mechanically or motor driven, in which case they will be productive of much less exhaust steam than if they are direct steam driven.

In a condensing plant only about one-eleventh or nine per cent of the steam generated by the boiler can be used for heating the feed water. In a condensing plant all of the steam from the engine is condensed with cold water and is discharged into the hot well. Some of the auxiliaries should be operated non-condensing so that their exhaust can be used for heating the feed water up to 212 deg. F. if possible. The temperature of this condenser discharge water which is now used from the hot well for boiler feed is about 120 deg. F. Therefore, to raise its temperature to 212 deg. there will be required only $212 - 120 = 92$ B.t.u. It is assumed that the open feed-water heater will be used. Hence, for these conditions the number of pounds of feed water which will be heated from 120 deg. to 212 deg. by 1 lb. of exhaust steam (which will give up 970.4 B.t.u. of latent heat in changing from steam at 212 deg. to water at 212 deg.) will be: $970.4 \div 92 = 10.6$ lb. That is, 1 lb. of the exhaust steam will heat 10.6 lb. of feed water to 212 deg. Now with each pound of the hot-well water which is fed into the boiler, the 1 lb. of condensed steam which is used in raising the temperature of the hot-well water is fed in with it. Hence, for each 1 lb. of exhaust steam utilized for feed water heating there is fed into the boiler: $10.6 + 1 = 11.6$ lb. of feed water at a temperature of 212 deg. F.

This being true, there is only $1/11.6 = 8.6$ per cent, or say, 9 per cent of the total steam generated by the boiler which can be used for heating feed water. Obviously, then, the ideal economic condition for a condensing plant is to have auxiliaries which will furnish exhaust steam to an amount equivalent to about 9 per cent of the steam generated by the boiler. It should be understood that the 9 per cent is the ideal value which applies only for the water temperature conditions specified for this example. But for every ordinary case the value will be somewhere around 9 per cent. Losses, such as condensation and the like, for which no allowance has been made in this problem, will tend to increase above 9 per cent the amount of exhaust steam which can be used for feed-water heating.

It is reasonable to expect that the auxiliaries in the average plant will supply at least the amount of exhaust steam required for heating the feed water. Every effort should be exerted to produce just enough exhaust steam to heat the feed water up to 210 or 212 deg. F. But there should be no exhaust in excess of this. If there is, it will be wasted.

United States Geological Survey recently issued a report on the ground waters of southern California, prepared by G. A. Waring and covering the San Jacinto and Temecula basins. It contains a general description of the geology and water resources of the region and a detailed description of the ground waters in each of 11 districts into which the region is divided.

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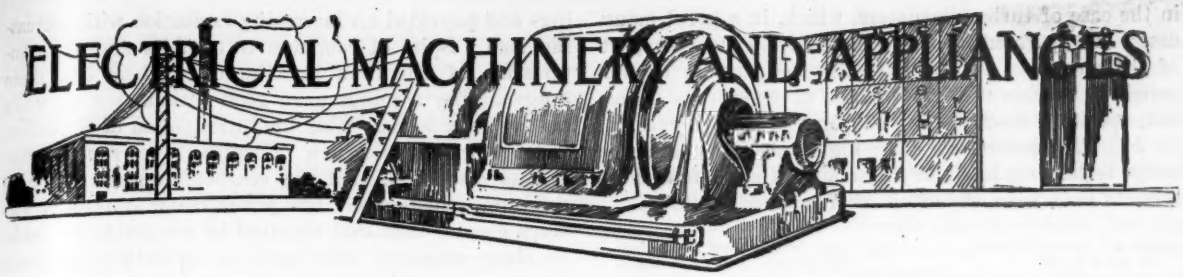


Alternating-Current Regulators---III

REASONS FOR MAINTAINING CONSTANT VOLTAGE; THE UNDERLYING THEORY OF GENERATOR REGULATORS. BY V. E. JOHNSON

THE EFFECT of voltage variation on incandescent lamps is very marked. In Fig. 1 are given data from various lamp manufacturers. It will be noted, for example, that a 10 per cent voltage reduction decreases the wattage 15.6 per cent and the candlepower 31.2 per cent. Thus, the power station suffers from a reduction of output, while the consumer has his candlepower reduced far out of proportion to the decrease in his bills. In order for the customer to obtain 100 per cent illumination, he would be compelled to use 23 per cent more energy.

FIG. 1. EFFECT OF VOLTAGE VARIATION UPON CANDLEPOWER, ENERGY CONSUMPTION AND LIFE OF INCANDESCENT LAMP

% Normal Voltage	% Normal Candle Pr.	% Normal Watts per C. Power	% Normal Wattage	% Normal Life	% Normal Current
90	68.8	123.1	84.4	466	94.0
91	71.6	120.3	86.0	393	94.6
92	74.5	117.6	87.6	332	95.2
93	77.5	115.0	89.2	283	95.8
94	80.5	112.6	90.8	238	96.4
95	83.5	110.2	92.4	205	97.0
96	86.8	108.0	93.9	177	97.8
97	90.0	105.8	95.4	153	98.2
98	93.4	103.6	97.0	130	98.8
99	96.8	101.8	98.5	114	99.4
100	100.0	100.0	100.0	100	100.0
101	103.5	98.2	101.6	87	100.6
102	107.0	96.4	103.1	76	101.1
103	110.5	94.6	104.6	66	101.6
104	114.4	92.9	106.1	57	102.1
105	118.4	91.2	107.6	50	102.6
106	122.5	89.5	109.3	44	103.2
107	126.7	87.9	111.0	38	103.8
108	131.0	86.5	112.7	33	104.4
109	135.6	84.7	114.6	29	105.0
110	140.3	83.1	116.3	26	105.6

Considering now a station which delivers current during the evening only 3 per cent below normal, if the average evening output during a 2-hr. peak is 1000 kw., the reduction due to low voltage would be (1000 ÷ 95.4 per cent) — 1000, or 50 kw. If the rate is 5 cents per kilowatt-hour, this would amount to $5 per day, or $1500 per year (of 300 days), or enough to pay interest and depreciation charges at 10 per cent on an investment of $15,000.

Low voltage does not affect motors as markedly as it does lamps; nevertheless their capacity and torque are seriously reduced. The torque at any slip (including 100 per cent slip or starting torque) varies as the square of the applied primary voltage. Changes which take place in the speed-torque characteristic with variations in voltage are, however, largely dependent on the design of the motor, so that it is not possible to tabulate the results, as was done in the case of lamps.

METHODS OF VOLTAGE CONTROL

HAVING thus established the necessity for proper voltage maintenance, various means of securing this may be considered.

Early alternator designers followed what appeared to be a logical rule in building their machines, by arranging to operate them above the knee of the saturation curve. In Fig. 2 is shown a typical voltage characteristic in which relations existing between excitation and terminal voltage are indicated. From A to B the curve is a straight line—indicating that for this range the voltage varies directly as the applied excitation, measured in amperes. From B to C the curve droops; at this

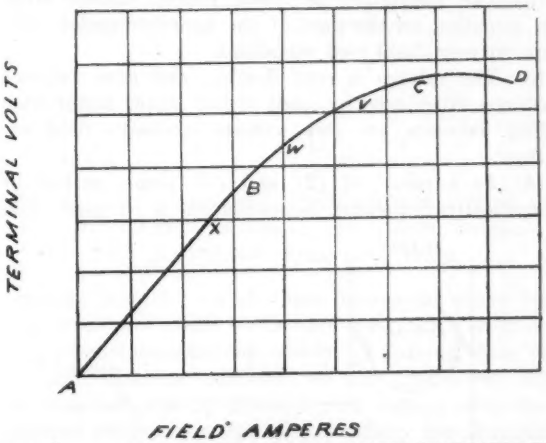


FIG. 2. TYPICAL ALTERNATING-CURRENT-GENERATOR-VOLTAGE CHARACTERISTIC CURVE

point, an ever increasing increment of excitation is necessary for a given increment of voltage. From C to D (which condition is seldom if ever reached in actual practice) the curve is horizontal; no amount of excitation will produce any increase of terminal voltage when this stage is reached. It is obvious that if normal voltage is at V, it will require a considerable change of excitation to produce a given increase or decrease of generated voltage, and the machine is "stable." Changes of load and their accompanying changes in field distortion are to a considerable degree neutralized, and the generator has as a result inherently good regulation.

With the changes in station loads, new methods of design became necessary; the modern generator is operated on a straighter portion of the voltage characteristic, as at W in Fig. 2. This change is still more marked

in the case of turbo alternators, which, in a great many cases, are operated on the comparatively straight part of the curve, as at X. It is not the purpose of this article to explain why this change of design was made; but, resulting from it, the following conditions exist:

(1) The generators have high reactance, and are much better able to stand the strains of accidental short circuits than were the older low-reactance machines.

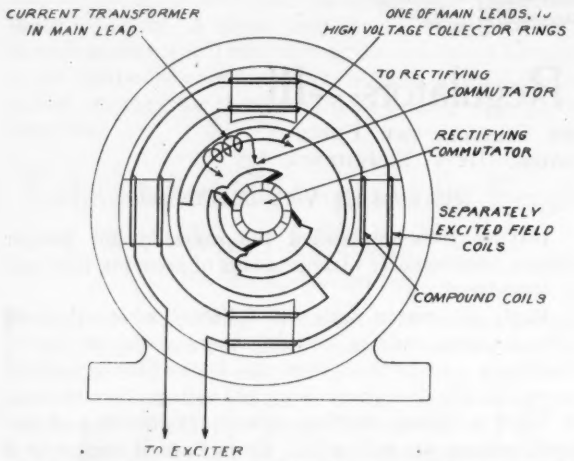


FIG. 3. DIAGRAM OF CONNECTIONS OF ALTERNATOR FITTED WITH COMPOUNDING WINDINGS

(2) The regulation is much poorer, necessitating close attention on the part of the operator under even comparatively slight load variations.

(3) The voltage is very flexible, and even extreme conditions introduced by loads of low power factor with lagging currents are met without excessive field excitation.

(4) As a result of (2) and (3), some method of automatically adjusting the excitation is in most cases

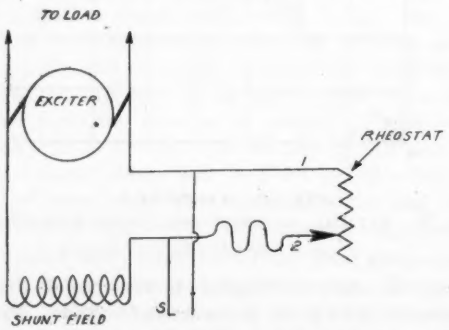


FIG. 4. DIAGRAM OF CONNECTION OF SHUNT WOUND GENERATOR EQUIPPED WITH RHEOSTAT SHORT-CIRCUITING SWITCHES

necessary, in order that varying loads may not produce voltage fluctuations.

Among the earlier forms of automatic regulation was that of compounding of the alternator fields. In Fig. 3 is shown how this was done. The alternator fields were provided with two sets of windings, one of which was excited from a separate source, while the second or compounding winding had passing through it the current from a rectifying commutator. This rectified current was proportioned to the current in the generator windings and provided an increasing excitation with increasing load. Spite of commutator troubles and the complication of operation introduced by their use, these compounding windngs gave good satisfaction on unity power factor loads. With the introduction of the induction motor, however, new difficulties were encountered. It was discovered that the compounding necessary to maintain voltage under low power factor conditions was much greater than that required by non-inductive loads.

Many attempts were made to introduce automatic regulators controlled by the voltage of the bus and acting directly on the alternator field rheostat. The seeming simplicity of the problem invited experimenting, but of all the schemes developed none proved a success until an ingenious operator discovered that he could—by leaving the exciter rheostat set for a desired voltage and short-circuiting its terminals with a screwdriver—build up the exciter voltage to normal almost instantly, and then by removing the short circuit leave the exciter operating along at the proper point.

On this simple phenomenon is based the modern generator regulator. In Fig. 4 is shown a d. c. generator

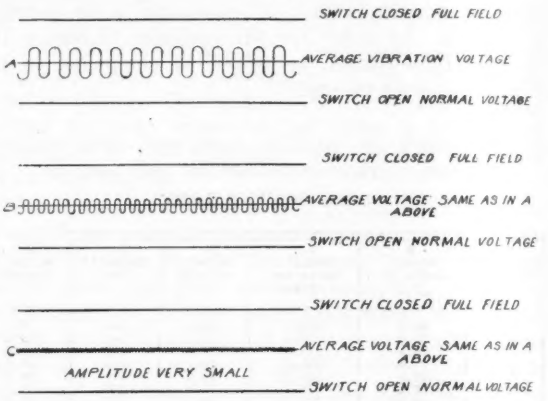


FIG. 5. EFFECTS OF VARYING RATIO OF TIME RHEOSTAT IS SHORT-CIRCUITED TO TIME IT IS CLEARED

with switch S connected across the rheostat terminals. If the rheostat is of such capacity that at position (1) "all in" the voltage of the exciter drops to 2.5 per cent normal, and at (2) the voltage is held normal, the conditions which can exist are as follows:

With switch closed, generator will operate at full field, say, 150 per cent normal voltage.

With switch open and rheostat set at (2), voltage is normal.

It is readily conceivable that if switch S be opened and closed rapidly and continuously, the voltage will be wavering between 100 and 150 per cent. If a definite relation is maintained between the time "closed" and time "open," this wavering voltage will have a fixed average value and will appear graphically as in a, Fig. 5. If the ratio of "closed" to "open" is maintained but the speed of operation of the switch is increased, the result will be as b, Fig. 5. If, by mechanical means, this rate of vibration were increased to an extremely high value, it would be possible to maintain a voltage in which the fluctuations are unnoticeable except by the use of very sensitive instruments. See c, Fig. 5.

If, now, the frequency of the vibration be maintained

at this high value, but the ratio of "closed" to "open" be increased, it is obvious that the voltage would be maintained at a higher value, the maximum being obtained where the switch is closed 100 per cent of the time. On the other hand, if the ratio of "closed" to "open" be decreased, the voltage decreases until, at the minimum value, the switch is open 100 per cent of the

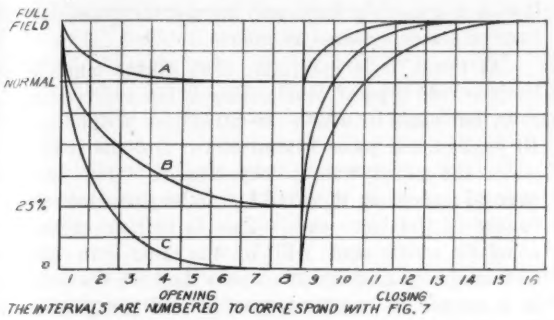
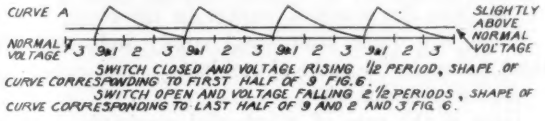


FIG. 6. RELATION BETWEEN EXCITER VOLTAGE AND TIME OF OPENING AND CLOSING SHORT-CIRCUITING SWITCH WITH VARIOUS RHEOSTAT SETTINGS

time and the exciter operates at normal voltage, as determined by the setting of the rheostat at (2), Fig. 4. Until this rheostat is turned "in" still further, the voltage cannot be further reduced.

By setting the rheostat at the "all in" position, the minimum voltage becomes 25 per cent, in accordance with our arbitrary assumption in this case, and the range of adjustment possible to the vibrating switch is from 25


CURVE A
SLIGHTLY ABOVE NORMAL VOLTAGE
NORMAL VOLTAGE
3 3a1 2 3 3a1 2 3 3a1 2 3 3a1 2 3
SWITCH CLOSED AND VOLTAGE RISING 1/2 PERIOD, SHAPE OF CURVE CORRESPONDING TO FIRST HALF OF 3 FIG. 6.
SWITCH OPEN AND VOLTAGE FALLING 2 1/2 PERIODS, SHAPE OF CURVE CORRESPONDING TO LAST HALF OF 3 AND 2 AND 3 FIG. 6.

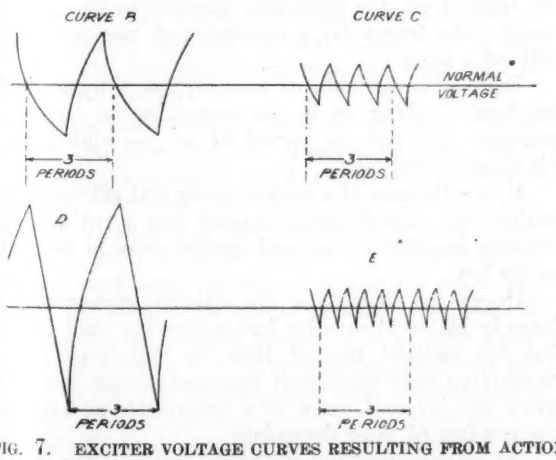


FIG. 7. EXCITER VOLTAGE CURVES RESULTING FROM ACTION ILLUSTRATED IN FIG. 6

to 150 per cent normal. We have here, then, in elementary form a method of controlling a. c. generator voltages—depending upon the characteristic of the vibration ratio of a switch which intermittently short-circuits the exciter rheostat. Theoretically, this method could be applied to the generator rheostat, leaving the exciter busses at constant potential; but, as previously stated, this would involve the use of heavy and consequently sluggish contact parts.

If to this rheostat short-circuiting device there now be added a controlling apparatus of such characteristics that it automatically varies the vibration ratio, with changes in voltage, the problem of an alternating current generator regulator is solved.

Considering as a concrete case the exciter described above: In Fig. 6 are shown a set of curves in which voltage is plotted against time, voltage being measured across the exciter terminals and the time being called 0 at the instant of opening or closing short-circuiting switch. The time intervals are immaterial, as the curves are qualitative, no attention being paid to actual values.

In A, B and C the initial voltage is that due to "closed switch" or full field conditions. In A the rheostat is set for normal voltage, in B it is set for 25 per cent normal, and in C the rheostat is removed, so that opening the switch opens the field. It will be noted that C decreases the voltage much more rapidly than B, and B more

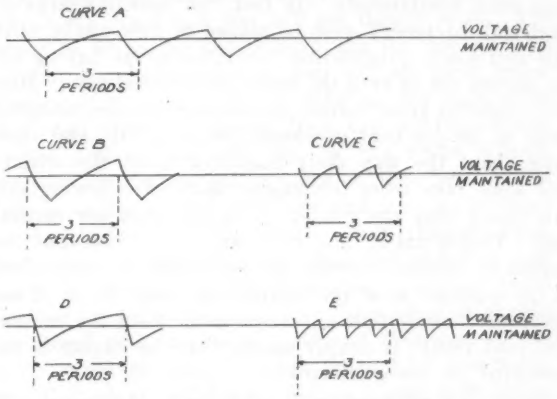


FIG. 8. EXCITER VOLTAGE CURVES RESULTING FROM ACTION ILLUSTRATED IN FIG. 6, BUT WITH VOLTAGE MAINTAINED NEAR FULL FIELD

rapidly than A. In all three figures the curve flattens out near its "finish"—the last few volts variation taking place comparatively slowly. Applying these curves to our vibrating regulator, we find that if we attempt to maintain slightly above normal voltage with the conditions shown in curve A prevailing, the changes will be sluggish in the "opening" half of the cycle and rapid in the "closing" half, as shown in the curve. The exciter voltage curve would resemble A in Fig. 7. The assumed time of one cycle is three periods, based on the units marked off in Fig. 6.

If curve B, Fig. 6, is used, both closing and opening take place on a much steeper curve, and normal voltage falls on a straight part of the graph. With the same period of vibration as under curve A conditions, the voltage wave would have much greater amplitude, as in B, Fig. 7. By increasing this frequency, however, a curve as in C, Fig. 7, would be obtained, which is evidently more sensitive than the curve of A, Fig. 7, without having any greater amplitude.

If C, Fig. 6, be used, the curve is extremely steep and a voltage wave, as D, Fig. 7, would result. Obviously a very high rate of vibration would be necessary in order to prevent an excessive drop in voltage. By using this high frequency, a curve, as E, Fig. 7, would result.

In Fig. 8 is shown a set of curves, A, B, C, D and E, corresponding to the same letters in Fig. 7, but with the assumption that the voltage to be maintained is near full field. In this case the sluggishness near the upper end of the "closing" curves is the controlling factor, so that it would not be possible to obtain sensitive regulation here, regardless of the setting of the field rheostat.

(To Be Continued)

Folly of Overloading Electrical Machinery

Advantages of Having Machines of Higher Rated Capacity Than the Load Requires

IT IS a great pity that electrical motors and generators do not pull up and refuse duty when the overload carried exceeds say 10 per cent. Far too much has been made in the past of the ability of electrical machinery to stand up to stiff overloads, and to carry such loads continuously. In fact, few men in charge of electrical machinery seem to realize as they ought, that this systematic overloading virtually means baking all the nature out of even the best class of insulation. Men who ought to know better will keep generators slogging away at 10 per cent overloads 10 hr. a day, and then brag about the way their machines stand the strain; and some men seem to imagine that by following out this policy they are getting a machine at a low capital cost. This is not so, and it is usually the case that the engine or turbine driving the set is not as economical at the overload as at the correct full load. Even if the overload consumption is rather better than the normal full load result, it simply means that the engine is too powerful for the generator.

Now any really first-class motor or generator will last 25 yr. if treated properly, and then be a good economical tool. In fact, a motor purchased second-hand, and put to drive economizer scrapers, has been run the last 12½ yr. with only two field coils replaced during that time. This good result was simply due to the fact that the motor was about 10 per cent above instead of 10 per cent below its work; so that even the hot atmosphere found near the economizer scraper gear did not ruin the insulation quickly. On the other hand, when one sees a generator of first-class make and 800 kw. capacity burst out in 8 yr. working, and then finds the insulation baked to death on the few coils which are not damaged, it follows that the persistent overworking of such plants is folly. Subsequent inquiry proved that it had always been the rule to work this set at from 850 to nearly 900 kw. Another case consisted of some induction motors carrying a very heavy load on the line shaft they drive, and often loaded very heavily owing to overheating of the machine tools. These plants are always giving trouble, and well they might. Just because they do not spit and groan, overload is piled onto them until they are simply worked and baked to death. An electrical machine is controlled very largely by its heating limit; and when a customer insists on cutting down the price of a motor or generator mercilessly, or persists in putting the load carried higher and higher, he should be made aware that he is forcing the designer of the plant to work very close up to the safe limit in order to offer a small and low-priced machine and that he himself is then doing all he can to swallow up this limit, or safeguard, by working the machine right up to the collar. In such cases, the heat developed in the windings cannot get away as fast as it is generated, so that the insulation is simply baked and baked, day after day, until it loses its nature, crumbles, and sooner or later falls away and leaves a path to earth. Then follows a short, a big flash, and three-quarters of the armature or stator conductors gone.

At times, it is inevitable that plants must be overloaded; this type of overloading is not referred to, however, but cases in which the plant was bought from 6 to 10 yr. ago, the price beaten down, and the load put up when the plant was in commission. One firm spent over $75 each on three 15-hp. induction motors, in the course of the last years. This is neither economy nor common sense, and will in the long run give non-technical mill and works owners the idea that electricity is a source of constant trouble and petty annoyance. In particular the engineer who is running a private plant against the competition of a large outside supply authority should avoid this policy as he would the plague. His only safety for keeping going as an independent man, is to see that there is freedom from trouble and stoppages, as well as economical running. These are all best obtained and maintained by keeping at least 10 per cent above one's load and not that amount under.

It Seems Ever Thus—But Why?

"He was the best man in the department, but—"
"He was generally such a careful employe, but—"
"He was the steadiest worker in the force, but—"

These are quite usual—and surely sad—comments which follow in the wake of accidents.

And we wonder why!

Here is the case of a splendid mechanic, knowing his trade from the primitive hammer to the modern turret—who forgot for a moment, and now goes about without a hand.

There's the instance of a steady, alert lineman—he has been climbing up in his occupation, in fact as in practice—who for the period of an eye-wink relaxed his thought, and fell.

Here's the case of a worker—long and efficient at his duties—who thoughtlessly stepped into a rut and now requires hospital service and special shoes to keep him on his feet.

Here's the example of the diligent worker who relaxes in his usual care for just a moment—and it takes but the smallest iota of time for dire consequences to start on their mission of pain and sorrow, snatching away the joy and peace of a happy life and stealing the comfort of those dependent.

As eternal vigilance is the price of liberty, so will it ever require constant care to rid us of the menace of Accidents, and their retinue of Pain, Sorrow, Grief, Disfigurement, Disappointment and Despair—a combination of enemies far more insidious than those that face nations—because they lie so stealthily in wait for each individual.

The A B C of Safety is ALWAYS BE CAREFUL.

—The Detroit Edison Synchroscope.

Further Experiences at the Glendale Power Station

A Letter From John Blake to Albert Wallace and the Reply. By G. H. Kimball

DEAR WALLACE: The work is picking up here a little more than when you left. The water is somewhat lower and I think that we will have to start the oil engine in a few days.

By following your advice, I was careful to see that we put the clutch back on so that it would run all right and it seems to be able to handle the load as it should. I can see that it is necessary to have the brake set up just right in order to keep the bushing from heating and I find that I can get it just right now. I am thankful for your help and I see what you were up against with all those things to look after. Is there not some way that pulleys and clutches could have been arranged so that they would not have to be repaired so often? It appears to me that it was a very poor arrangement and it probably seemed so to you.

I have been anxious to hear how the plant at Bridgetown is running and how the man Gooch turned out. It must be hard to have a man like him around, but there is a good chance to make a record there, I should think. Let me know something when you write.

Graham has started out to do something this time and has selected the 400-hp. steam engine. You remember how he talked when he came here about adjusting the valves. He said that an indicator should always be put on first and then the defects, if there were any, could be remedied by slight adjustments. Well he thought that he would do something this week Wednesday and he took the back covers off the exhaust valve chambers and then the ones on the steam chests and rolled her over to the centers; evidently he was not satisfied with the setting, for he began to make changes on the rods and nobody knows how they will work now. I'll bet she takes steam enough for two engines. I don't know why he should touch her now, for he has not run her any and she was doing well enough when you left; but that is his way and there will be more to come, I think.

We had a little difficulty with the pump on the jet condenser the other day, for Graham thought that it would be a good thing to run it a little and see how it would run. So when the steam was turned on, she started off all right and then he left it to work slowly and after a while he found that it was stopped and it would not start again no matter how much steam you gave it. We worked for nearly an hour and tried all sorts of stunts, but nothing came of it until John Kerns happened to come in and he squinted at the pump and said to Graham: "Haven't you been schooled on a condenser?"

Graham fidgeted a minute and then replied: "Yes, but not on that kind."

So Kerns stooped down and took a look at the valve gear and found what we all should have seen, that the adjustable bolt that connects the rocker arm with the valve rod, to rotate it, was loose so that it had lengthened so that the valve would not work. When this was screwed back to the original length, the pump went on as before.

I felt pretty cheap and it surprised Graham to have the trouble found so easily and it surprises me still more to see him fall down on a simple thing like that when he has probably seen and worked around many pumps of all sizes.

As I said, we are likely to start the oil engine any day now for Crandall, over at the gorge plant, says that he uses all of the water that comes along now; so if we don't have rain, the engines will have to help out.

Now let me hear from you soon and with best wishes for good luck, I remain,

Your friend, JOHN BLAKE.

MY DEAR JOHN: I am glad to hear that you got the clutch back so that it works to your satisfaction. I used to think that the care of the jack shaft with all of its pulleys and clutches was equal to one-half of the work in the plant and you will see that it is so. The manner of designing the pulleys was the poorest possible and if you look around, you will see three better examples in another place. I refer to the rope drive pulley that takes the power from the 400-hp. engine, and the pulleys that are run by the water wheels. Here you see the pulleys running on their own shafts which have their own bearings and are made large enough to allow the jack shaft to run through them without any friction, so that when the clutch is out, nothing matters. The hollow shafts are called quills and all of those pulleys that drive the generators should be equipped with the same layout and then most of the trouble would be over. I often thought of how much better that plant could have been laid out with all of the money that was spent, and we might have had one of the best for its size in the country.

About this place here, I have become better acquainted with Mr. Curly and he is not a bad sort but he wishes to delve into the very bottom of everything. I was working at the plant that is to be moved and Curly told me to go down to the one that was running and have Gooch come up here, as he wanted him to do something for him. I went down and told Gooch and then an order come along for him to stay there, so I hung around all the afternoon and then went down there the next day. I can see that Gooch does not hate himself very much for he has been telling how much he can do.

Today he asked me if I was going to have charge of the plant and I said that I believed that I was hired for that purpose and then he said: "I don't see why they don't give it to me, for I have kept their plant running for them all of the time since last fall and when the man in charge was afraid to stay with the engines." He kept on in a like strain and at the end I thought: "If he is as good as he says that he is, why did they wish to hire anyone else? He seems to know all that there is to know."

I told him that when I made the deal his name was not mentioned and if there was any doubt as to my standing, I was perfectly willing to do anything to make

things agreeable until such time as a decision was made. He said that he would not work as an assistant, but the idea was to keep two oil engine men on the job. So I am waiting for something to happen, for it seems likely that there will be a change before long.

The unit here is new and a good machine, but the adjustments have been neglected and it makes more noise than is necessary. She also smokes a blue smoke all of the time, which should not be except at light loads. I am going to see what causes that after a while.

I got a steam engineer's license the other day and I have been doing some running up at the main factory nights when there is no water, so Curly is more friendly than he was. I shall be interested to hear how the steam engine works after the valve adjustment.

I must close now so remember me to the boys.

Yours truly, ALBERT WALLACE.

Knocking in Gas Engines

CAUSES OFTEN DIFFICULT TO LOCATE. WHERE TO LOOK FOR THEM. BY MARK MEREDITH.

KNOCK in a gas engine is frequently a warning of approaching breakdown. For this reason it is generally inadvisable to allow an engine to continue running a moment longer than is absolutely necessary when a knock is heard. It would be interesting to know how many disastrous breakdowns, entailing personal injuries and stoppages of work, might have been prevented had the engineer in charge not failed to heed the warning given by a knock in some part of the engine.

In probably the majority of cases, knocking is the result of lost motion in some part or other of the engine. For instance, the connecting rod brasses may have become worn, or the flywheel keys may have worked loose, and so on. As a general rule the first thing the average engineer does when he discovers any knocking is to close up the big or the small ends of the connecting rods, or both ends if necessary, and in many cases this will cure the trouble.

It will occasionally happen with large engines, however, that after fitting new connecting-rod brasses a new and heavy knock will develop in the engine cylinder. This may usually be accounted for in the following way: The continual motion of the piston to and fro in the cylinder has worn away some of the metal of the liner, leaving a ridge at the part where the first piston ring moves up to each stroke. Since the new brasses are thicker than the old ones, the effect is to cause the piston to move a little farther up into the cylinder each stroke, with the result that the first ring strikes against the ridge each stroke, causing a heavy knock. Of course, if the engineer in charge has taken the precaution to fit liners behind the brasses where wear has taken place so as to maintain the correct centers, the trouble in question is not likely to arise.

To prevent this new knock it will be necessary to remove the ridge referred to by chipping and filing. If it be impracticable to do this early, the first ring may be removed from the piston until such time as the true remedy can be applied.

Sometimes the piston rings themselves will cause knocking or rattling through their being loose, and it is not always an easy matter to trace the knocking caused in this way. When, therefore, a knock cannot be at once located, it is advisable to test whether the piston rings are a good fit in their grooves.

KNOCKING CAUSED BY BADLY FITTED KEYS

LOOSENESS of the flywheel keys is a somewhat common cause of knocking in gas engines. The conditions of working in a gas engine are, of course, severe; much more so than is the case with a steam engine, and with the increased pressures and speeds now in vogue, it is no easy matter to get the keys to remain tight for long periods of running. The slightest amount of slackness is obviously serious as in addition to giving rise to more or less severe knocking, it involves risk of damage to the keys, and fracture of the wheel boss and possibly the crank shaft. Loose keys are always likely to be met with if the wheel boss has been bored slightly too large or at all out of true.

It is not sufficient that the flywheel keys be quite tight; they must be a perfect fit. In numerous instances, the keys have been found as tight as possible, but the flywheel was, nevertheless, slightly loose, and a heavy knock occurred in consequence. An interesting example presented itself when a large gas engine was reported to be knocking, and the owners, who were unable to locate the knock, arranged for a firm specializing in engineering repairs to look into the matter. The firm's men commenced their investigations by first removing the connecting rod and piston with the object of closing the brasses, but this was found to have been done already by the owners. The piston rings were next examined for slackness or breakage, but these were found to be in good condition and to fit perfectly. The flywheel key was then examined, but proved to be quite tight. As the cause of the knock could not be located, those concerned decided to give the engine a thorough overhaul. Yet after the work of overhauling had been completed, the engine, on being started up again, knocked as badly as ever. The cause of the trouble was, however, discovered shortly afterward by chance. The engine had been stopped again and the man in charge of the job happened to place his foot on one of the arms of the flywheel by way of a rest and in order to think the matter over. While in this attitude the man felt a distinct knock on the sole of his boot. This gave the clue to the solution of the trouble; obviously there must be some slackness or lost motion in the flywheel. Although the key had previously been found quite tight, a close examination of the key and its keyway were now made, and the examination served to show not only that the key was badly proportioned and badly shaped, but the keyway had been badly cut, being narrower in the middle than at the ends. In short, only a short length of the key was really effective in securing the wheel to the shaft, and this was the cause of the whole trouble.

It has already been pointed out that the continual motion of the piston to and fro in the cylinder gradually wears away some of the metal of the cylinder liner, leaving a ridge at the end of the travel of the first piston ring. In extreme cases the wear is so pronounced that the piston becomes quite slack in the liner, and this will sometimes prove to be the cause of the

knock. Thus, when the explosive mixture is fired, the force of the explosion causes the piston to shake against the internal surface of the liner, and a knock is thus likely to be heard each explosion stroke. A knock of this character can scarcely be regarded as serious, since no undue stresses are likely to set up on any of the parts. What is perhaps of more importance than the knock is the loss which will probably occur by leakage of the explosive mixture past the piston. The remedy for the trouble is, of course, to re-bore the cylinder liner and fit a new piston, or else to fit both a new liner and a new piston.

Poor Fit Between Valve Stems and Guides

One cause of knocking in gas engines, but one which is usually easy to discover, is undue clearance between the spindles of the different valves and the levers which operate the valves. When the valves are properly adjusted for lift they are first opened very gradually by the cams which work the levers, and then more rapidly. When, however, there is a considerable amount of clearance between the valve spindles and the levers the latter, instead of coming into contact at a moment when they are moving very slowly, only do so when the rate of motion has become comparatively great. The result is that the levers, instead of coming into gradual contact with the spindles, bang against them, thus tending to cause a knock. If now the valves lift easily the force of the blow is relieved and the knock will be of little importance; but if, on the other hand, much force is required to lift the valves the knock is likely to become somewhat severe. In the case of the gas and air valves, comparatively little force is required to open the valves, because each valve opens at the commencement of the suction stroke, when the piston is really reducing the pressure against which the valves have to lift, and so assisting in opening them.

Now the case is quite different with the exhaust valve. This valve has to open at the end of the explosion stroke when the pressure in the cylinder is considerable. Since in addition to this pressure the pressure of the spring which keeps the valve down on its seat during the admission, compression and explosion strokes has also to be overcome, not to speak of the weight of the valve itself, it is not difficult to understand that the force required to open the valve is considerable. Hence, when there is much clearance between the exhaust valve spindle and lever the knock resulting may prove to be somewhat serious. The force of the blow is, of course, transmitted to the teeth of the skew wheels which drive the cam shaft, and if these teeth are much worn, as they frequently are in engines which have seen much service, risk of breakage of the teeth is incurred. Knocking of a somewhat similar nature to the foregoing will sometimes occur as the result of undue wear of the rollers against which the cams work, the latter banging against the rollers once each cycle.

Knocks Caused by Early Ignition

Another somewhat common cause of knocking in gas engines is early firing of the explosive mixture. Thus, if the charge is fired much before the piston reaches the end of the compression stroke, the general effect is to tend to check suddenly the motion of the piston, so that if there is the slightest lost motion in the moving parts a more or less severe knock is likely to occur each cycle.

Too early firing may, of course, be caused through improper adjustment of the ignition arrangements, but it will sometimes occur when the adjustment is quite in order. The trouble will then generally be due to the deposit of carbon on the valves, the cylinder end and on the piston.

When the trouble referred to is experienced it is therefore well to look for evidences of carbon deposit, and should any be discovered it should be removed at the earliest opportunity. Satisfactory removal can as a rule only be effected after the piston has been withdrawn. It is far from wise merely to loosen the deposit and trust to this being blown out through the exhaust valve. Unless the deposit is positively removed by hand after the piston has been withdrawn there is every probability that the engine will soon suffer severely from scored piston rings and cylinder walls.

The Point of View

The Two Marines. Making Dreams Come True, in Spite of Handicaps. By H. A. Cranford

IT'S ALL in the point of view that a fellow takes of misfortune. A few nights since I happened to be in the company of two marines who had each left a leg in France.

They were discussing what they were going to do now that they were back, and under such different conditions and circumstances from when they left. One of them was complaining that as he had learned the trade of locomotive fireman, he would have to learn something entirely different as he couldn't see how he could expect to follow his old trade, and if he could still do the work that the railroads would not accept him on account of his handicap. He said that he had asked for numbers of positions in other lines that were open, but as his aducation was limited, the jobs that he could get, he couldn't hold. He was very bitter and cursed the fate that handled him so roughly.

When he had somewhat subsided, the other fellow said, "Well I didn't lose much when they cut my foot off. It was so full of corns that I lost a lot of time from work, and had for several years, and now that it is gone, I can work steady, and the additional time that I will get to put in will compensate for the smaller wage I am now having to accept."

I asked them both why they did not accept the government's offer to teach them new vocations. The first replied, "Because there is too much discipline connected with everything that the army has anything to do with, and I swore that if I ever got my discharge, I would never put my name to anything that the army has anything to do with."

The other fellow said that because of his mother's health it was almost impossible for him to be away from her, and that he had thought it all out, and decided that he could make it someway. While he didn't mention it, I found out the next day that he was going to a night school studying law. He had always wanted to be a lawyer, but had never seen how he could manage it; but since he has lost the limb, he has been able to see a

chance. And it is a safe bet that he will be a lawyer, and a better one than he would have been had he had the opportunity before this war. The first fellow I mentioned had a much better education than the last one. But without someone who can handle him right, in three or four years the first one will be begging and the last one will be a successful lawyer.

I often hear the expression, "There goes a fellow that never amounted to anything until he got crippled," and when I come to think of it, I know several fellows myself that never got very far, until they became crippled. In some cases, the person is perfectly competent to succeed, but is either reckless or thoughtless and doesn't amount to much. When his accident happens it has a steadying effect, and he cuts out a lot of his former foolishness. It is an old saying, that "any fool can make money, but it takes a wise man to save it," and it takes a pretty hard jolt from fate to make us "wise" sometimes.

Personally, I know that my life never would have been as satisfactory to myself or family as it has been, if I had not become a cripple. It took me long years to come to the point where I could say this with thorough conviction, but I can say it now, right from the heart. There may or may not be such thing as fate, but whether there is or not, there is nothing to gain by cursing it.

That first marine that I mentioned, was simply too full of can't, couldn't and if. The second one never used either word, and anyone with any foresight, or imagination, can see the difference in the future of the two men. If your environment is not what you would have it be, don't criticize and complain, but get busy and find a remedy. And when you find the remedy, have backbone enough to apply it. I have never seen what the botanist calls a spineless cactus, but I can imagine something about what it looks like when I look at some of the cripple beggars, and hear some cripples cursing fate.

A friend pointed to a man passing us and remarked: "There goes a dreamer. His dreams are beautiful. He sees things before any of us think of them, but he is a failure." In a short time another man passed. He pointed to him and remarked: "There goes a man who made one of the other fellows' dreams come true. He is a success." Dreams cannot amount to anything unless you have the confidence in yourself to put them through. Dreams are necessary. They open up new ideas. But if they are allowed to go with the dawn, like the dreams of sleep, they are a detriment. We would be better off without them. If on the other hand a man dreams of flying across the ocean, and then makes the attempt, even though he fails, he has helped the world. When most of the dreamers told their dreams, the world scoffed at first, but they made them come true. When you dream, employers will at first scoff, but YOU must make them come true.

I once had charge of an engine the foundation of which was wrong. It seemed to be all right when it was set years before. But the long years of service had shown that it was insufficient. I blocked the engine to hold it in place and drilled and blasted out the old foundation, and built one that years of experience had taught me would be sufficient for the changed conditions under which the engine was working. I tightened the engine down, and it is running. To you boys that are maimed, let me say that you are like that old engine. Conditions have changed with you. And the probabilities are that the foundation that you built for your life in the younger days of inexperience was not too secure anyway. So hold your life right where it is for a few days, get rid of all the changed foundation and build under a better one, one that will meet the changed conditions that you will have to work under. There is plenty of material at hand, if you have the brains and experience to use it. When the job is done things will run for you even better than they did before, and you will feel proud of the job you've done.

All the ingenuity of man cannot return the spilled milk back into the vessel exactly as it was. Then why cry over the spilling of it? Simply accept matters as they are? No, but proceed to fill the vessel as before, or possibly better than before. Crying and complaining instead of helping, will hinder, because you are losing time that's valuable. Forget the past and its possibilities as you saw them, and dream of the future. Then put your dreams in practice. No one can tell you exactly how to do it. If you have mind enough to see visions, you should certainly have backbone enough to make the visions real. Fight against self pity or self-consciousness. Refuse in a polite way all sympathy. Learn to concentrate your mind on the problems that confront you. Force yourself to be a close observer. Draw a lesson from everything with which you come in contact. Learn to get your argument ready before the other fellow is ready. Cultivate patience and above all believe implicitly in yourself and your ability to do and whether you are maimed or whole, the devil himself cannot hold you down, for

"Full many a race is lost,
Ere even a step is run,
And many a coward fails,
Ere even his work's begun.
Think big and your deeds will grow.
Think small and you'll fall behind.
Think that you can, and you will:
It's all in the state of your mind."

THE AMERICAN CHAMBER OF COMMERCE IN LONDON reports that at a meeting of coal consumers and representatives of all branches of the industry and trade, at the Newcastle Commercial Exchange, a resolution was carried against the Nationalization of coal mines.

The argument was introduced that the United States was putting coal on board steamers at about $5.50 per ton, as against Britain about $15 per ton. American cargo was now being discharged at Stockholm. America might even supply London cheaper than Durham or Northumberland did.

The American Chamber of Commerce in London points out that the facts cited coincide with the statement reported to have been made recently by the manager of certain United States coal companies, who is now in Great Britain. This expert stated that American coal could be put on ships at Newport News at about $5 per ton, and with normal freights could be sold in London at about $7.50 per ton, with profit. He also stated that the American output ran sometimes to seven times as much per day as the British output, and expressed astonishment at the restrictive output policy in Great Britain.

The Diesel Engine---V*

FACTORS AFFECTING COST OF GENERATING POWER. BY HERBERT HAAS

AS REGARDS generation of power with heat engines, the following factors influence the cost:

1. The fuel consumption of the generating units.
2. The B.t.u. price.
3. The size of generating units and of the station.
4. The station-load factor or the ratio of yearly output in kilowatt-hours to the maximum possible yearly output in kilowatt-hours.
5. Capital or fixed charges, comprising interest on the capital invested in the power plant and amortization.
6. Operating expenses comprising cost of labor, lubrication and maintenance.

The influence of these factors on the cost of generating power with small Diesel engines is shown in Figs. 9 and 10. One-hundred-horsepower and 200-hp. engines which drive industrial machinery direct from belt have been selected. The engines are loaded at an average of about 80 per cent of their rated capacity, a condition commonly found in industrial plants. Labor is figured at $3 per man per 8-hr. day. The installation cost, including building space for housing the engine, is taken at $100 per horsepower of installed capacity for the 100-hp. engine and at $90 for the 200-hp. engine. All costs are referred to a unit of 1 hp. operating one year of 8760 hrs. The total costs of operating the engine for shorter periods are also shown. The figures show that capital charges are constant, regardless of load; that the fuel cost is proportionate to the operating time, and that the labor and maintenance charges are nearly proportionate to the operating time.

The costgraph of the 200-hp. engine shows the influence of size on the reduction of capital and of labor charges. There is no difference in the fuel consumption of the two engines, as the fuel economy of both is the same. Figure 11 shows for the 100-hp. engine the operating costs for different engine-use periods reduced to costs per horsepower corresponding to these use periods or load factors. Figure 12 shows similar data for the 200-hp. engine. The influence of a reduced number of operating hours, which is synonymous with a reduced output of horsepower hours, is at once apparent. The fixed charges increase the unit power cost rapidly at low-use factors. For the fuel cost a basic price of $1 per bbl. of 320 lb. has been used. To what extent higher

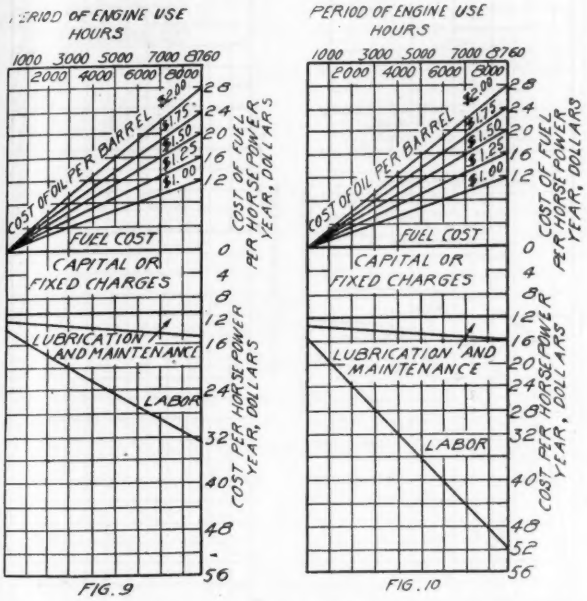

PERIOD OF ENGINE USE HOURS
1000 3000 5000 7000 8760
2000 4000 6000 8000
COST OF OIL PER BARREL $2.00 $1.75 $1.50 $1.25 $1.00
FUEL COST
CAPITAL OR FIXED CHARGES
LUBRICATION AND MAINTENANCE
LABOR
COST PER HORSEPOWER YEAR, DOLLARS
COST OF FUEL PER HORSEPOWER YEAR, DOLLARS
FIG. 9
FIG. 10

FIG. 9. COMPARATIVE COSTS OF DIFFERENT ITEMS IN THE OPERATION OF A 100-HP. DIESEL ENGINE AT A MEAN 80 PER CENT LOAD

FIG. 10. COMPARATIVE COSTS OF DIFFERENT ITEMS IN THE OPERATION OF A 200-HP. DIESEL ENGINE OPERATING AT A MEAN 80 PER CENT LOAD

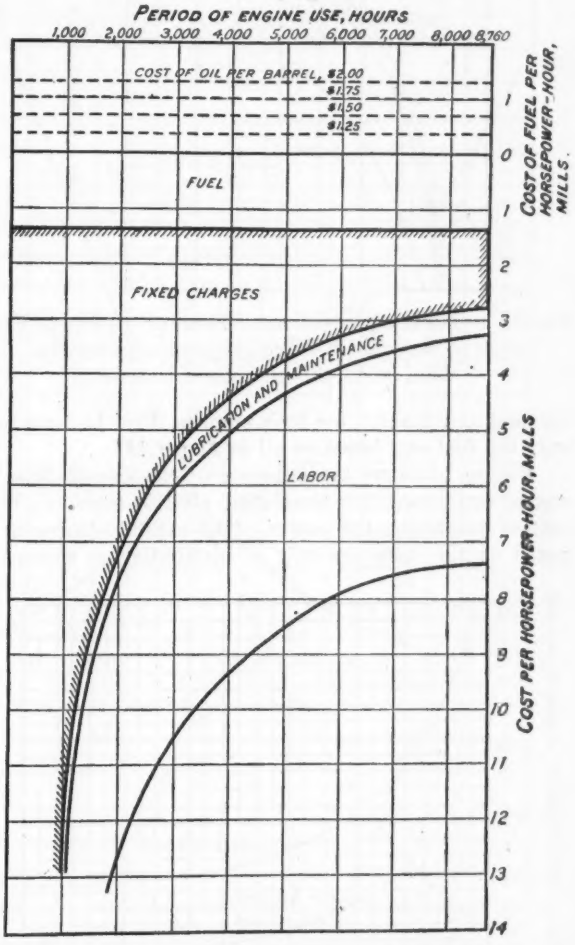

PERIOD OF ENGINE USE, HOURS
1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 8,760
COST OF OIL PER BARREL, $2.00 $1.75 $1.50 $1.25
FUEL
FIXED CHARGES
LUBRICATION AND MAINTENANCE
LABOR
COST OF FUEL PER HORSEPOWER-HOUR, MILLS
COST PER HORSEPOWER-HOUR, MILLS

FIG. 11. OPERATING COSTS FOR DIFFERENT ENGINES—THE PERIODS REDUCED TO CORRESPONDING HORSEPOWER HOUR COSTS, 100-HP. DIESEL ENGINE

*Abstract of Bulletin No. 156 of the Department of Interior, Bureau of Mines.

fuel prices increase the power cost is indicated by broken lines above the base line. The cost increment proportionate to the higher fuel price would have to be added to the horsepower-hour cost as shown in the graph below the base line (in which the fuel cost at $1 per barrel is already included) for any use factor. As this cost increment is the same for both engines, Fig. 11 includes only the fuel cost based on oil at $1 per bbl.

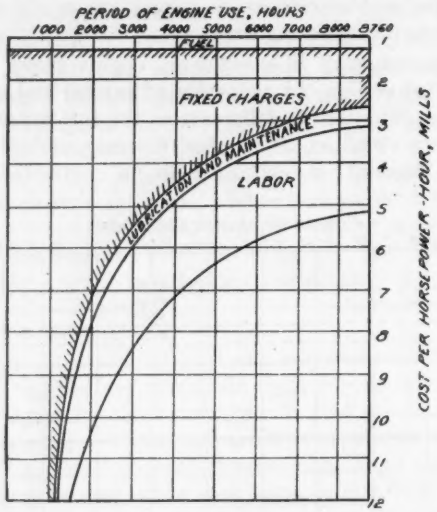


FIG. 12. OPERATING COSTS FOR DIFFERENT ENGINES—THE PERIODS REDUCED TO CORRESPONDING HORSEPOWER HOUR COSTS, 200-HP. DIESEL ENGINE

Figure 14 shows the influence of the size of Diesel-engine equipments for generating electric power on the cost of producing the power. The capital charges are based on the costs per unit of installation as given in Fig. 13. To obtain the best operating economy and flexibility, each station is considered as being composed of at least three units, each with a capacity of one-third of the aggregate station capacity. With an increase or decrease in load during different periods of the day, one or more units can be thrown into or out of action.

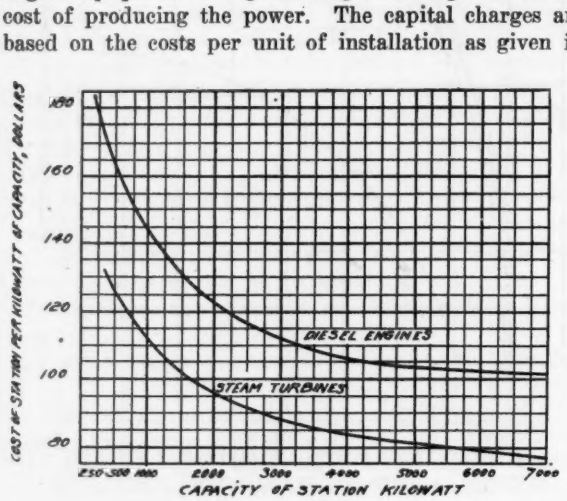


FIG. 13. COMPARATIVE COSTS PER UNIT OF DIESEL ENGINE EQUIPMENT AND OF STEAM TURBINE EQUIPMENT FOR GENERATING ELECTRICITY

Figure 15 shows the cost of a kilowatt-hour for different station-load factors and for stations of different sizes, the data being based on the kilowatt-year costs in Fig. 14. The fixed charges are represented by full lines marked KW.F.C., and the costs for labor, lubrication and maintenance are represented by broken lines marked KW.L.M. The fuel costs have not been added, as these are practically constant at 2 to 2½ mills per kilowatt-hour for a load factor of 100 to 25 per cent, with fuel oil costing $1 per bbl. of 320 lb. For oil of a higher price the proportionate higher fuel cost can easily be calculated.

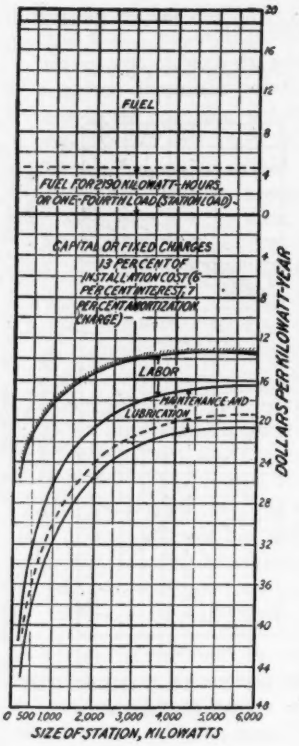

FUEL
FUEL FOR 2190 KILOWATT-HOURS, OR ONE-FOURTH LOAD (STATION LOAD)
CAPITAL OR FIXED CHARGES (13 PER CENT OF INSTALLATION COST (6 PER CENT INTEREST, 7 PER CENT AMORTIZATION CHARGE))
LABOR
MAINTENANCE AND LUBRICATION
DOLLARS PER KILOWATT-YEAR
0 500 1000 2000 3000 4000 5000 6000
SIZE OF STATION, KILOWATTS

FIG. 14

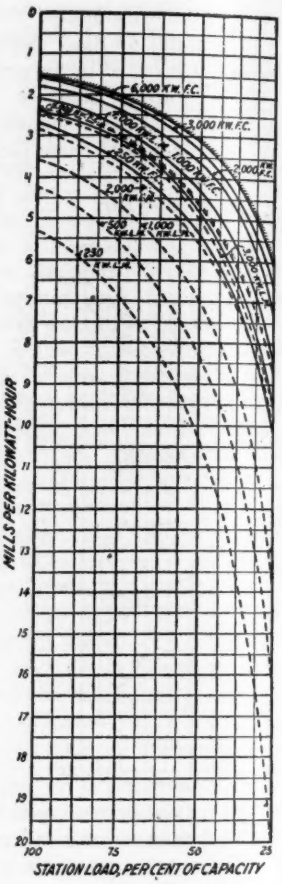


FIG. 15

FIG. 14. CURVES SHOWING COST OF KILOWATT YEAR (8760 KW.-HR.) AT FULL LOAD AS INFLUENCED BY STATION CAPACITY

FIG. 15. CURVES SHOWING COST OF KILOWATT HOUR IN MILLS AT DIFFERENT STATION LOAD FACTORS

Combined charges for capital, labor, lubrication and maintenance can be read direct for any load factor from the broken-line curves. The line representing kilowatt-hour costs for a 6000-kw. station has been cross-hatched to make it distinct. As the size of a station materially influences the cost of power production, different sized stations are indicated by separate curves to make clear the influence of station size and station factor or the power production cost.

Figure 16 presents a comparative analysis of the factors controlling the cost of generating power in me-

dium-sized (9000-kw.) central stations using either Diesel engines or steam turbines. Figure 17 shows the comparative efficiencies of the two types of prime movers. For the steam turbine highly favorable operating conditions have been taken; namely, a steam pressure of

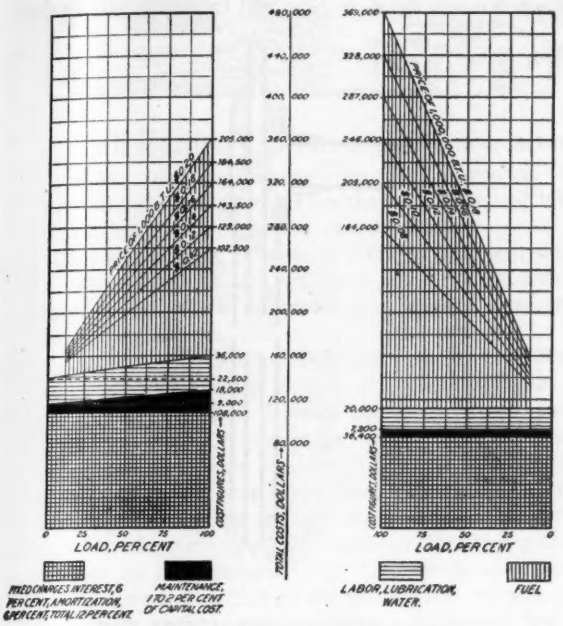

LOAD, PER CENT
LOAD, PER CENT
TOTAL COSTS, DOLLARS
FIXED CHARGES, INTEREST, 6 PER CENT, AMORTIZATION, 6 PER CENT, TOTAL 12 PER CENT
MAINTENANCE, 1 TO 2 PER CENT OF CAPITAL COST
LABOR, LUBRICATION, WATER
FUEL

FIG. 16. COMPARATIVE COSTS OF OPERATION OF DIESEL ENGINE AND OF STEAM TURBINE INSTALLATION FOR GENERATING POWER

180 lb. per sq. in., a steam temperature of 600 deg. F., a temperature of 60 deg. F. at the inlet for the circulating water for condensing, and a vacuum of 96 per cent. Of the three variables, steam temper-

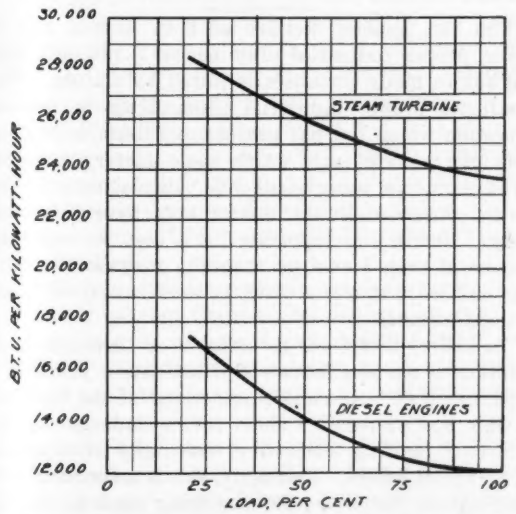


FIG. 17. COMPARATIVE OPERATING EFFICIENCIES OF DIESEL ENGINES AND OF STEAM TURBINES

ature and cooling-water temperature, the last two affect the economy most, as is shown in Fig. 18, from which the increased or decreased fuel consumption can be figured for the other operating conditions than those assumed. The percentage of fuel increase (above the base influence on the total power cost with low B.t.u. price and low load factor, particularly as applied to stand-by plants, which are operated only occasionally or to take care of recurring peak loads. The installation cost of such plants must be kept as low as possible so as to avoid heavy capital charges distributable over a relatively small output of kilowatt hours for the station. Such conditions favor the steam turbine.

3. An exception to consideration 2 is when the constant readiness of the Diesel engine makes it preferable, installation cost being of secondary importance. Here the cost of keeping boilers under steam continuously

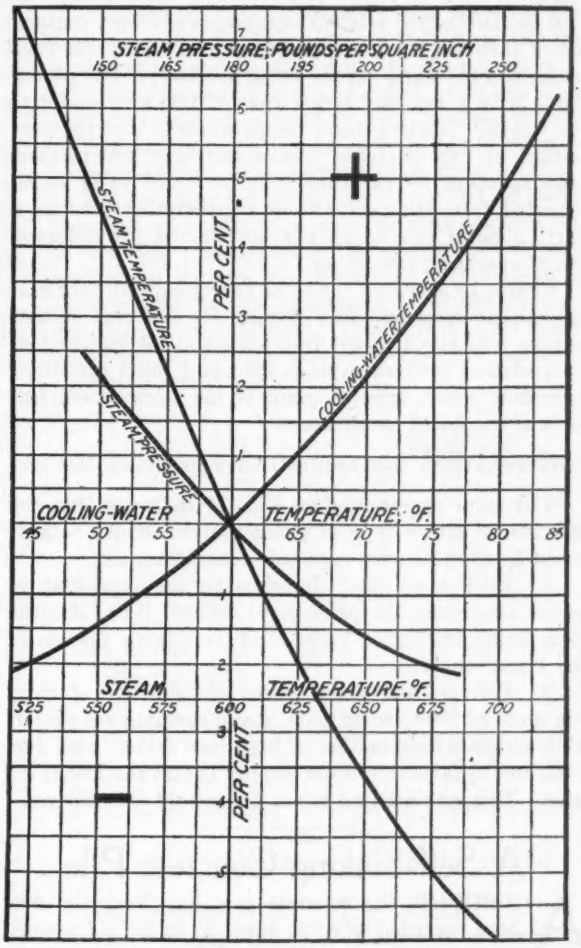


FIG. 18. INFLUENCE OF OPERATING CONDITIONS ON PERFORMANCE

would have to be balanced against the difference of interest charges on steam-turbine plants as compared with those on Diesel-engine plants.

4. The prime movers most logical for power plants situated at the source of the fuel, either in the oil field or at the coal mine, and therefore enjoying the advantages of a cheap fuel supply, are those costing least to install—that is, steam turbines. The fuel expenditures will be comparatively less than interest and redemption charges, provided that a satisfactory supply of cooling water is available for condensing.

5. In many instances combination plants using

Diesel engines for supplying the continuous and nearly constant main load, and steam turbines for furnishing periodically occurring peaks by the use of high-duty boilers with large water and steam spaces, capable of being forced when necessary, will prove most profitable. The periodical peaks may be taken care of by a turbine floating on the line and operating in parallel with the Diesel engines that supply the main load and operate constantly at or near full load.

6. Up to capacities of 1000 hp., steam turbines can compete with Diesel engines only for special uses, such as supplying exhaust steam for heating. For larger plants, of 1000 to 10,000 kw. capacity, careful analysis must be made of the relative advantages of Diesel engines and of turbines, a knowledge of the load factor, the fuel prices, and the water supply being necessary. For power plants with a capacity larger than 10,000 kw., comprisline marked "cooling-water temperature") and the percentage of fuel decrease (below the base line marked "cooling-water temperature") to be added to or to be deducted from the performance consumption used as a starting point can be readily ascertained for different sets of operating conditions.

Figure 16, showing the total yearly capital, lubricating, maintenance and fuel charges for different station factors, indicates that the fuel price and the station factor (relation between average load and rated capacity) determine which type of plant is the more economical for a given set of conditions.

Considerations Governing Choice of Prime Movers

The data represented in Fig. 14 indicates that the selection of either type of prime movers should be governed by the following economic considerations:

1. Fuel is of chief influence on the total cost of power when both the price per 1,000,000 B.t.u. and the load factor are high. These conditions favor the use of the Diesel engine.

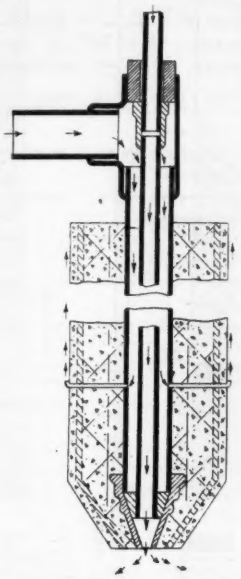
2. Interest and amortization charges are of chief ing units of 6000 kw. or more, steam turbines are preferable, unless a combination of high load factor, high fuel cost, and unfavorable water supply favors the Diesel engine. This combination is not frequently encountered.

A Self-Sinking Concrete Pile

Although the concrete pile has from the first been regarded as much superior to the old wooden ones, difficulty has always been encountered in driving them. They cannot be driven in the ordinary manner, as the tops would certainly be damaged, and even when the tops are protected, the body of the pile is likely to become damaged to the extent of exposure of the reinforcing to the water. It is to overcome these disadvantages that the self-sinking concrete pile, described in a recent issue of the Scientific American, has been developed.

The body of this pile is constructed in the usual way of reinforced concrete. Through the center of the body is a 4-in. pipe reaching nearly to the bottom, inside of this being a 2-in. pipe ending in a nozzle at the bottom of the pile. The 4-in. pipe is closed at the lower end, but open to a number of jets through the sides of the pile. These jets have their nozzles turned upward.

In sinking or planting a pile, water at a pressure of 200 lb. per square inch, is forced out through the nozzle at the bottom, loosening the earth and forcing it aside. If necessary to reduce the friction as well as carry upward the excess earth, water under a similar pressure is forced through the 4-in. pipe and the small vertical jets.



SECTION THROUGH SELF-SINKING PILE

Should any object be encountered which impedes its progress, the pile may readily be lifted and allowed to drop to clear the way again. As soon as the pile has reached the desired depth, and the water flow stops, the loose wet earth starts to settle and wedges itself tightly around the pile, holding it securely in place. A pile of this type can be sunk in from 5 to 7 min.

For the general welfare of both worker and employer, proper industrial illumination is not only desirable but in many instances required by statute. What constitutes proper industrial illumination is, however, a question which few but professional illuminating engineers can answer, and which some factory managers, works engineers, superintendents, electricians and others vitally concerned in the matter may have given some study. Recent developments have been so rapid that systems of even 3 or 4 yr. standing may now be out of date and may, in many cases, be modernized with profit to their owners.

In order, therefore, to assist in a thorough understanding of modern industrial illuminating practice, the Department of Electrical Engineering of the University of Ohio has prepared a short correspondence course in industrial lighting, consisting essentially of a series of six technical letters. Primarily, this is a course of study assignments, frequent reference being made to that most up-to-date form of technical literature, the trade publication.

At the close of each letter a number of practical problems are presented, answers to which are given in subsequent letters. In this way the most vital points are impressed upon the mind of the student and, due to the nature of the problems, he is made to appreciate more fully the value of the theoretical discussion.

Ball Bearing Operation and Lubrication

FROM TIME to time articles have appeared in the various technical journals on the operation and lubrication of ball bearings, and statements have been made which would tend to mislead users of ball bearings. It is the province of this article to correct such erroneous impressions which engineers and others have gained from these articles.

The kinematics of ball bearings presents no difficulties and is exactly similar to that of a planetary gear train with gears having an infinite number of teeth, as illustrated in Fig. 1. Assuming the usual application in which the inner race of the ball bearing rotates and the outer race is stationary, the inner race becomes the sun, the balls are the planets, and the outer race the annulus or internal gear. It is quite apparent that in a planetary system, as illustrated in Fig. 2, there is absolutely no circumferential sliding of the gears when the sun pinion is rotated, and the same operating conditions are present in the ball bearing. It must be remembered that there are no arms connecting the planets with the sun or the balls with the inner race, and the relative positions of the raceway and balls are never fixed, so that the balls are always in pure rolling contact with the two races.

The slight amount of sliding friction present in ball bearings occurs between the balls and the retainer, and this friction is materially reduced by the presence of lubricant. There is also an additional source of sliding friction in ball bearings, due to the area of contact which exists when the bearing is supporting load.

Ball bearings are manufactured with such extreme precaution that absolute point contact exists when the bearings are operated unloaded; however, immediately upon the imposition of load there exists a very definite contact zone which causes a very slight amount of sliding friction.

This friction is greater in the deep groove, single row type of bearing than in the double row type, and for this reason the former is particularly adapted for applications where shock and heavy loads are encountered, while the latter is more favorable for high speed applications.

Tests have shown that the sliding friction in ball bearings is extremely small and that a ball bearing without lubricant has a lower coefficient of friction but a materially shorter life than on operating with a lubricant.

If this sliding friction between balls and retainer and that due to the compression of the material under load were not present and if the possibility of corrosion of the highly polished balls and raceways by the presence or intrusion of moisture in the bearing housings were eliminated, there would be no necessity whatever for the lubrication of ball bearings, and their successful operation would not be impaired in the least.

The argument has frequently been advanced that the load supported by ball bearings is transmitted through a film of oil which exists between the raceways. Such transmission of forces is impossible when one considers that the lubricant between the balls and raceways is free to flow in all directions as soon as compression occurs under the balls. It is therefore quite apparent that loads in ball bearings are transmitted by metal to metal contact and are distributed over an appreciable area, due to the close conformity of the grooves of the raceways to the ball surface, and the slight deformations of the raceways due to the high elasticity of the steel used in ball bearing manufacture. Thus it is that the theoretical point contact of balls and raceways never exists under operating conditions.

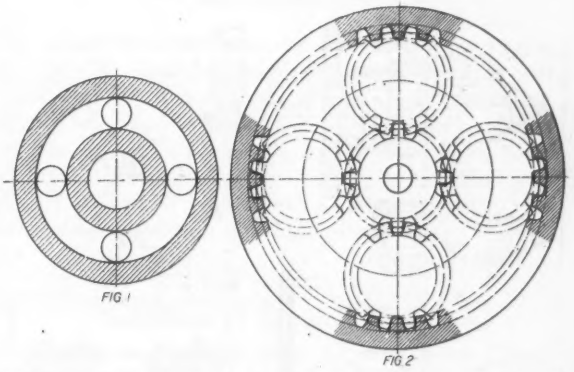


FIG. 1. BALL BEARING, A MODIFIED FORM OF PLANETARY GEAR TRAIN
FIG. 2. OUTLINE OF PLANETARY SYSTEM

The selection of the proper lubricant for ball bearings is of extreme importance in order to insure against the corrosion or pitting of the highly polished raceways and balls by the presence of free acid or alkali. Extensive experience and exhaustive tests have shown that a lubricant containing a free acid content not in excess of 0.10 per cent and no alkali content should be employed.

Current practice in the lubrication of ball bearings is to employ grease for low speeds, and oils for speeds in excess of 1500 r.p.m.

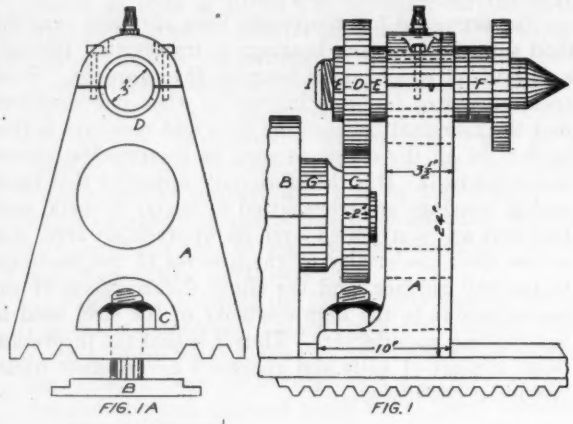
That the lubrication of ball bearings and the selection of a proper lubricant play an important part in the life and service of the bearings cannot be emphasized too strongly, and careless choice and improper and infrequent application of lubricant cannot be condemned too vigorously.

H. E. BRUNNER.

Attachment for Increasing Swing of Lathe

HEREWITH is represented an attachment for increasing the swing of a lathe. The design is not expensive and it better than using blocks, which mean disconnection of the head and tail stock, which should be avoided whenever possible. The advantage gained is that the engineer or machinist can handle a breakdown job in his own plant.

Figures 1 and 2 show the side view of this attachment, consisting of the cast iron standards, whose dimensions are given in the sketch. These castings are machined to fit the ways of the lathe bed, then bored for spindle bearings D, Fig. 1A. It is best to bore them in



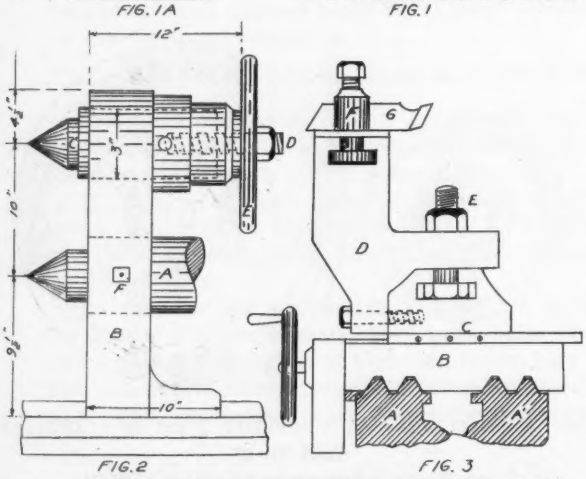


FIG. 1. SIDE VIEW OF ATTACHMENT FOR HEADSTOCK
FIG. 1A. END VIEW OF ATTACHMENT FOR HEADSTOCK
FIG. 2. ATTACHMENT FOR TAILSTOCK END
FIG. 3. METHOD OF RAISING TOOL POST

a horizontal boring mill, in order to assure proper alinement. The brass bearing for spindle I, Fig. 1, has a bore of 3 by 3½ in. and an outside diameter of 4 in. Spindle I is made of C. R. M. steel, casehardened and ground, the head end bored to a No. 3 Morse taper for center and the spindle threaded the same as lathe head spindle for face plate.

The rear end of the spindle is threaded with two threads, one for locking and adjusting spindle in housing by means of the ring nut E, and the other for locking the spur gear D. The spur gear C is threaded to fit lathe spindle G, which transmits the power to spindle I and face plate or chuck F. B is the lathe head stock.

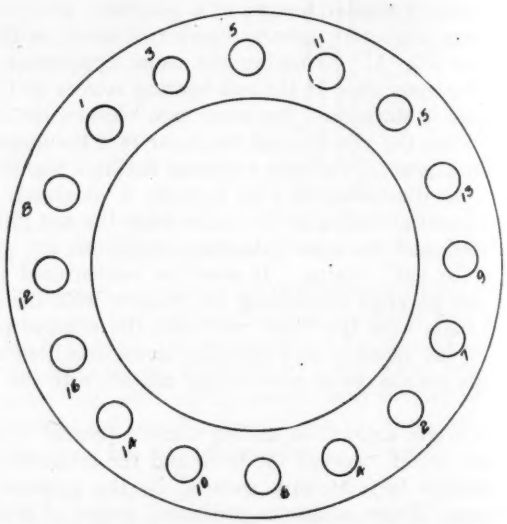
Figure 2 shows the tail stock. The casting is the same as in Fig. 1, excepting the top partition for tail stock spindle; this is bored for the spindle sleeve C, the bore being 3 in. in diameter. The spindle D is 9 in. long by 1½ in. in diameter and threaded to ¼-in. square thread. The casting is also bored central to original tail stock center and to fit tail stock spindle sleeve A, which may be inserted in the hole and locked by the set screw F, making the two tail stocks support each other.

Figure 3 shows the tool rest, carriage and lathe bed. The tool rest D is so designed as to give the tool a solid foundation. The rest is attached to the original rest C by means of the lock bolts H and E.

OTTO DORTHEN.

Standard Practice for Tightening Up Bolts

WHILE it is generally appreciated by engineers and pipe fitters that it is highly desirable to pull up flanges and other bolted parts evenly so as to prevent distor-



ORDER IN WHICH BOLTS ON FLANGES ARE TIGHTENED

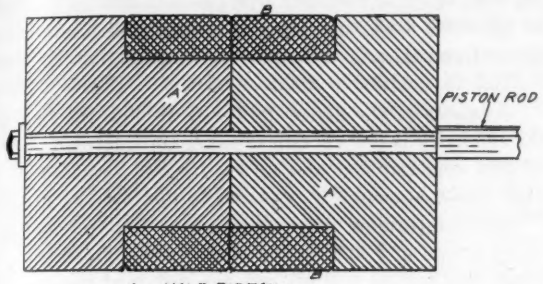
tion or other strains, it frequently happens that no particular effort is made to arrive at any standard practice in tightening up such nuts and bolts. Engineers usually attempt to make some sort of even distribution of the "pulling up" process and let it go at that.

Instead, it is well to follow some standard which seems to give the best results. In our plant we have adopted a standard practice in tightening up bolts as enumerated on the accompanying sketch. While at first adherence to the schedule as outlined slowed up work a bit, it was not long before the bolts were being pulled up properly as a matter of habit, instead of the haphazard method usually employed. M. A. SALLER.

A Quick Pump Repair Job

UNEXPECTEDLY and at a time when I needed it badly, my 6 by 10 by 8-in. boiler feed pump started to run away; opening the water end, I found the ball and piston rings gone to pieces. I had no new ones, neither could I have any made that day; so, after giving the matter

considerable thought and trying to devise ways and means by which I might get the pump working again, I decided to take the plunger apart. This I did, and in place of the ball and piston I used two rings of 1-in. hydraulic packing in the manner indicated in the accompanying drawing. This I accomplished by removing one-half of the piston, placing the packing rings on each half and then re-assembling the piston, taking up on it and locking it in place by means of the end nut.



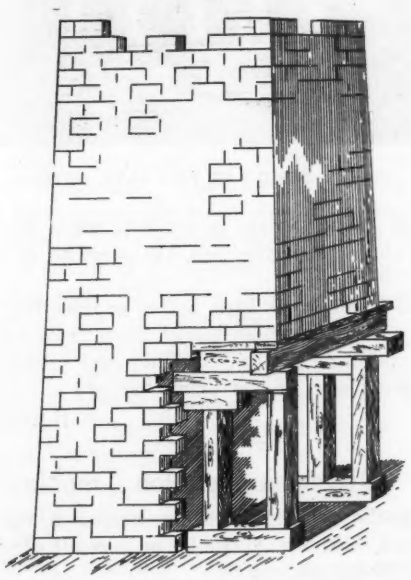
SHOWING APPLICATION OF HYDRAULIC PACKING

Twenty minutes later the pump was running, and has since given no further trouble. R. F. MUELLER.

Felling a Brick Stack

THE ACCOMPANYING sketch indicates the manner in which a brick stack 90 ft. high was torn down. Thirty feet of the brick was removed by hand, thus leaving 60 ft. to be cared for.

As shown, the base was torn out on three sides and braced with 10 by 10-in. oak blocks each 2 ft. long, the blocking having been placed on the side toward which it was desired to have the chimney fall.



SHOWING BRICK STACK PREPARATORY TO FALL

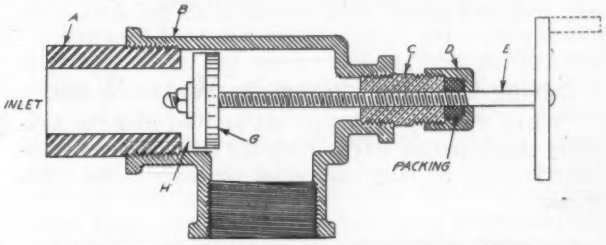
The blocking was well soaked in kerosene and then ignited, and as the blocking became consumed it crumbled, with the consequence that, due to the absence of sufficient support, the stack fell.

This is by no means a new method, but it occurred to me that possibly the readers of Power Plant Engineering would be interested. A. C. WALDRON.

A Serviceable Homemade Valve

THE VALVE shown herewith can be made by any engineer and will give excellent service on air, cold water, or other liquid lines containing no acids which corrode or dissolve iron or leather.

In the sketch, A is an extra-heavy iron pipe nipple, filed as square and level as possible on the inner or face end; B is a reducing tee; C is a piece of iron rod drilled out and threaded with a straight bolt tap for spindle E, and threaded with a pipe die on the outside; D is a pipe cap, drilled for the valve spindle and acts as a packing gland; G is an iron washer screwed onto the valve rod; H is a sole leather washer held against G by a washer and nut, as shown.



SECTION OF HOMEMADE VALVE SHOWING SCHEME OF CONSTRUCTION

To reface the valve, unscrew the extra-heavy nipple and reface it. If it is desired to use hot water, it will be necessary to turn the end of the nipple absolutely true in a lathe and to use a fiber washer. An old valve wheel can be used as a handle, or the rod can be bent, as shown by the dotted lines. A valve of this kind was used on a cold-water pipe carrying 100-lb. pressure, and gave as good service as any high-priced valve.

JOHN JAMES.

Protection of Blowoff Pipes

I SEE that on page 739, Aug. 15 issue, John Thorn says that many of these blowoff coverings have been suggested by different men for many years past; but I must say I never saw the one I suggested in the July 15 issue, and the reason I tried it this way was to keep from burning the blowoff pipes on a set of return tubular boilers, as I had quite a bit of trouble of this nature.

He also asks how the ends of the brick are kept from resting on the horizontal pipe, when laying the brick along the horizontal pipe. They are laid three or four higher than the pipe, and the brick cover is then laid. It starts the vertical brick pier and I never use any mortar in laying the brick up, and never had one of them knocked down from any cause.

Then, again, if he ever tried this method of protecting the blowoff pipe, he will find that there is very little draft around the blowoff pipe after it has been in use for a short time, or at least I have found it so, and I prefer this way above all others, even the "old reliable" way of connecting up the blowoff as he shows, for I have taken down pipes that were connected this way after they had been run for 6 to 8 months and found

them practically full of a very hard scale, and I must say that I never have found it so with the method I suggested, having run blowoff pipes for four or five years; they were good for longer.

I once heard this question asked: Why is it the pipes to water column do not scale badly? The answer was that the water was stationary and from the head. So I prefer no circulating pipes on blowoffs with which I have to deal.

I always make a practice of examining the exterior of the boiler every three months and always go into the boiler every time it is off for cleaning, which is every two weeks, and I have yet to see the man who gives the hammer test every time a boiler is off for cleaning. It is true that pipes can become badly corroded from the outside without being noticed until they are dangerous; just so of the boiler shell, as all shells are covered with something or other, and one never thinks of taking this covering off to examine it, and there have been bad accidents caused from corrosion of the shell.

L. A. COLE.

Saving Coal By Preventing Water Waste

WHEN THE low water period arrived and the auxiliary steam station was started, the crew at this hydroelectric plant got busy and calked the leaks in the waste gates.

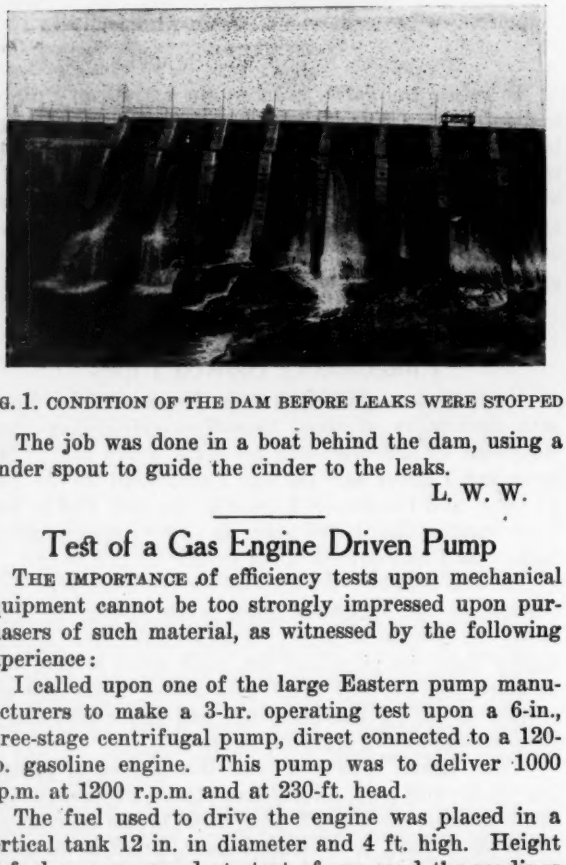


FIG. 1. CONDITION OF THE DAM BEFORE LEAKS WERE STOPPED

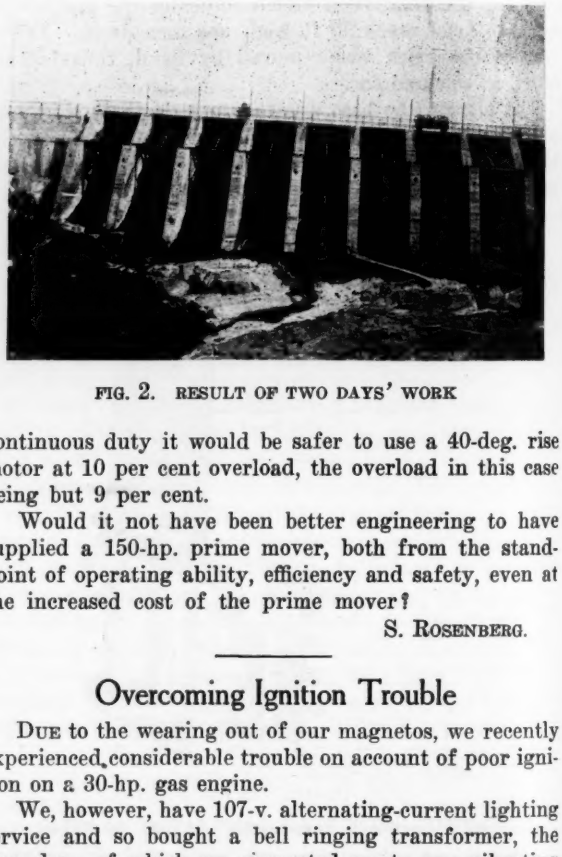


FIG. 2. RESULT OF TWO DAYS' WORK

The job was done in a boat behind the dam, using a cinder spout to guide the cinder to the leaks.

L. W. W.

Test of a Gas Engine Driven Pump

THE IMPORTANCE of efficiency tests upon mechanical equipment cannot be too strongly impressed upon purchasers of such material, as witnessed by the following experience:

I called upon one of the large Eastern pump manufacturers to make a 3-hr. operating test upon a 6-in., three-stage centrifugal pump, direct connected to a 120-hp. gasoline engine. This pump was to deliver 1000 g.p.m. at 1200 r.p.m. and at 230-ft. head.

The fuel used to drive the engine was placed in a vertical tank 12 in. in diameter and 4 ft. high. Height of fuel was measured at start of run, and the readings made at the end of each hour were subtracted from the previous height. This gave the height of fuel consumed. The amount of fuel consumed was then calculated as follows:

$$\frac{\text{Height in inches} \times 6 \times 6 \times 3.1416}{231}$$

For every inch of height in a tank of 12 in. diameter we have 0.49 gal., and therefore used this as a constant to multiply by the height observed.

The fuel consumption of the type of engine used in this test is ¾ pint per hp.-hr., or with the 120-hp. engine it should be 11¼ gal. Actual observation, however, showing the engine to consume 16.4 gal. per hour, I asked for an efficiency test, with the following result:

Total Head	G.p.m.	B.hp.	Water hp.	R.p.m.	Efficiency
310.5 ft.	1000	130.8	78	1200	59.8%

Analysis of the above data will disclose the fact that the efficiency is low enough to cause considerable increase of fuel consumption and operating cost, because of the high brake horsepower required to operate the pump.

For continuous duty ordering a 120-hp. engine to carry a load of 130.8 hp. pump is poor engineering. No doubt this engine will operate the pump at the excessive load, but not for very long without burning the bearings and scoring the cylinders. If this outfit were for standby fire duty only, then it would make small difference as to the operating cost and our only concern is as to the ability of the outfit to furnish water for a short period of time, or, if fortunate, at no time. For continuous duty it would be safer to use a 40-deg. rise motor at 10 per cent overload, the overload in this case being but 9 per cent.

Would it not have been better engineering to have supplied a 150-hp. prime mover, both from the standpoint of operating ability, efficiency and safety, even at the increased cost of the prime mover?

S. ROSENBERG.

Overcoming Ignition Trouble

DUE to the wearing out of our magnetos, we recently experienced considerable trouble on account of poor ignition on a 30-hp. gas engine.

We, however, have 107-v. alternating-current lighting service and so bought a bell ringing transformer, the secondary of which we connected up to our vibrating coil and spark plug. Since then we have experienced no further trouble.

With this scheme we obtain a voltage range of from 1 to 25 v.

B. C. WHITE.

Feed Water Connections

NOT LONG ago I was consulted by an engineer in reference to what was thought to be boiler feed pump trouble, in connection with a recently installed boiler. At times the feed pump worked extremely bad. I analyzed possible causes of such troubles, such as leaky suction line, poor packing, improperly seating valves and valve seats, but nothing would fit the case. The possibility of the water becoming at times too hot for the pumps to handle was considered, but I was informed that the heater could only heat the water to about 190 deg. F. at any time. "Jack," I said, "at what time does this trouble occur?" "There is no special time," he replied. "Sometimes it is before the noon hour and at other times it is in the afternoon. The pump gets one of these spells and the piping seems to jar and bang, and at times a most violent water hammer will occur."

Having traced the trouble from the water heater through the pumps and to the check valve at the boiler, I paused and thought for a moment; then asked if the check valve at any time hung up or refused to work. "No," he replied, "I am sure that it is not check valve trouble."

"Jack," I said, "how many gages of water do you carry in your boiler when running, and do you try to keep the same amount, as near as possible, at all times?"

"I most certainly do," he replied, "and with two gages on the dot at all times."

"Did you ever notice your water gage closely when this pump trouble occurred?"

"No," was his reply.

"Well, my friend, I am sorry to tell you, but I am very much afraid that your pipe fitter has put one over you, not intentionally, but either from a lack of experience or carelessness. Go back to your plant, and with tomorrow's run hold the water in your boiler at two gages and a half and make absolutely sure that it is on the dot all day long, as you say. Then after your day's run, call me by 'phone, and I am sure your answer will be that your pumps have worked beautifully all day."

According to his promise, he did, the reply being as I had prophesied. That being Thursday night, I advised him to cool his boiler down Saturday evening and prepare it for a Sunday morning's internal examination. I promised to be there to show him where the trouble lay, and told him to be sure and have his pipe fitter on the job. I looked the boiler over carefully, noted the position of the water column with its gauge glass, and saw at what height the boiler feed pipe entered the boiler. I turned to the pipe fitter and asked him the question, "Where did you go inside of the boiler with the end of your feed pipes?"

He looked at me hesitatingly and replied, "I did not go anywhere with it. That is only a nipple screwed into the boiler."

"Well, my dear boy," I said, "as you have all day to make the necessary connections, go take that short nipple out, cut a new one, cutting twice as many threads on it as on the boiler end of the old one. Screw it in tightly, making sure that your lock nuts are packed and well tightened on both the inside and outside. Screw a coupling onto it inside the boiler, then screw another piece of pipe into the coupling, allowing the end of it to go to the rear of your boiler, there placing an elbow, and another piece of pipe allowing it to go either half way down into the water betwen the tubes, or down into the mud drum."

When I had finished giving my instructions, my friend turned to me and said, "For the love of Mike, what has all of this got to do with pump troubles?"

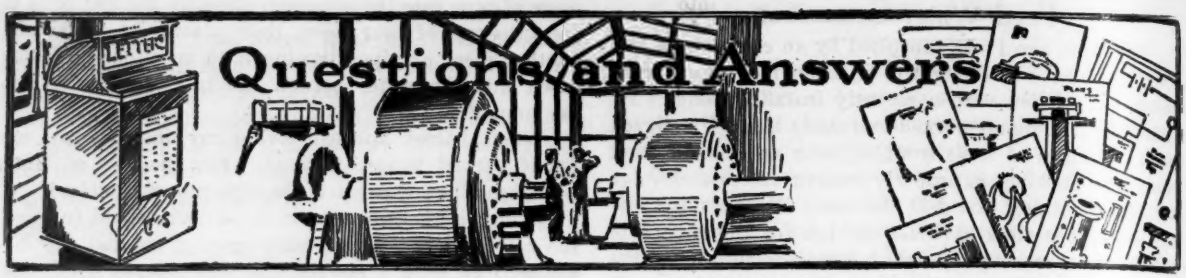
Bringing him into a position where he could fully see the relative positions of water gage glass and the discharge feed pipe, I showed him how simple it all was. When he was carrying 2½ gages of water, the feed line was lower than his water level in the water, and when he carried less than that amount, his feed water entered above the water line, thereby causing steam hammer. A few days later I was informed that the pump was running like a brand new automobile. H. W. ROSE.

Method of Banking Fires

BANKING FIRES is a matter of great importance in saving time, money and labor. Pushing back the live coal to the bridge-wall and covering it over with green coal, especially soft coal, is a mistake. This kind of a bank will lie dead over night and probably Saturday afternoon and Sunday, allowing the boilers to cool down and reducing the pressure. On hauling those banked fires down again, probably one or two hours before starting time, it will take a good many shovelfuls of coal to get the pressure up to where it belongs. There are other things, however, that will waste coal. The blowoff and other valves leading from the boilers may be leaking, allowing the boilers to lose water during shut-down time; and to make up for this, one is likely to have to let a large quantity of cold water into the boilers before starting the fires. This water should be supplied beforehand through a heater when the plant is in operation.

Following is my method of banking fires: I do not push the live coals to the bridge-wall, but cover the fire all over with green coal (this is what we call banking fires flat) half an hour before shutting down, allowing the pressure in the boilers to drop 15 to 20 lb.; then I open the furnace doors wide and close the dampers and the ashpit doors. We close all valves but the stop valves. The pressure in the boilers varies only from 5 to 10 lb. during the night. I claim that this method of banking fires saves the brick lining and also the boilers from sudden contraction and expansion in getting steam up before starting. Many firemen think that this method makes the fire hot to clean before starting, especially in summer. In the morning we open all dampers and push the fires back to the bridge-wall. We then close the furnace doors and let the front of the fire burn down to the ashes, which takes from 5 to 7 min.; then we clean the fire, which is cool at the front. I believe this is a good method, as it has proved so in this plant. M. M.

THERE ARE 200 engineering societies in the United States, with a total membership of 100,000, the annual dues amounting to $1,000,000. There are 200 other societies more or less connected with engineering and having many engineers as members. Probably 100,000 other engineers do not belong to any society.—Compressed Air Magazine.



Cause of Boiler Pitting

WE RECENTLY opened up one of our return tubular boilers and found the tubes badly pitted directly under the manhole. The rest of the tube surfaces were in a comparatively good condition. These same tubes had been scaled recently and we found the scale formation all on one side of the boiler or bank of tubes. There was almost no scale on the left side bank of tubes and only on the extreme right bank of tubes and on especially about four rows of tubes at the top was the heavy scale found. What would cause this sort of action in a boiler? That is for the scale to form in one place only and the pitting to occur directly under the manhead and nowhere else?

I may state that in so far as the pitting is concerned I noticed that one of the joints directly over the manhead of this boiler leaked condensation badly until the steam was turned on long enough to take up the header and this water of condensation had been running onto the manhead of this boiler which was cut out at the time and was cold. I arranged a trough to carry off this water; but when I went to remove the manhead for the inspector to enter, I found that it was not tight. Would the water if it dropped through and fell on these upper tubes cause pitting? The header valve also leaked and condensed steam in this boiler which was cut out, and I believe that it was the combined action of this dripping of condensation onto these tubes directly under the manhead that caused the pitting. The boiler while cut out was not filled with water. What is the opinion of readers on this theory? N. E.

Formulas Regarding Flow of Fluids

KINDLY supply me with formulas showing:

1. Weight of water discharged through an orifice.
2. Weight of steam discharged through an orifice.
3. Velocity of steam through an orifice.
4. Velocity of water through an orifice.
5. How may I find the temperature of a mixture of condensed steam and water when the steam and water are mixed at different pressure and temperature?
6. The "range" of an injector varies with the vertical lift and temperature of the feed water. How would you find (a) the range of an injector; (b) the vertical lift when the range of injector is known; and (c) the temperature of feed water delivered to the boiler when the temperature of the supply water and the boiler pressure is known?
7. What are the advantages of granulated cork as an insulating material?
8. For insulating cold storage compartments are shavings preferable to hair felt? What are their relative merits? G. P. T.

ANSWERS

IN REPLY to the inquiries included in your letter, the following information is submitted:

1. $W=62.4\ (c\sqrt{2gH\times a})$ is a commonly accepted formula for the weight of water discharged through an orifice, in which W=pound of water discharged per second; 62.4=weight of one cubic foot, c=co-efficient of discharge allowing for velocity and contraction, a=area in feet of rectangular or circular orifice, g=the acceleration of gravity (32.16). H=height of head, measured from center of orifice to the surface. The value c varies according to the head measured and the shape of the orifice, but 0.60 is an average figure.

For velocity of water in feet per second, $V=c\sqrt{2gH}$.

2. The deduction of the flow formula for steam differs from that for water on account of the fact that a gas carries intrinsic energy due to its expansive property, which must be accounted for in the equation of energy. The theoretically correct flow formula is deduced in various works on thermo-dynamics. It includes necessarily a coeffieient c to allow for contraction and losses, as is the case with water passing through an orifice. For gas, however, the value of c is very uncertain, especially for high pressures, there being insufficient experimental data on this quantity.

When the pressure drop between the two sides of the orifice is small, the volume of the gas changes but little, and consequently only little intrinsic energy is delivered to influence the flow. Under these circumstances, the intrinsic energy may be ignored, and an equation deduced similar to that for water, namely $V=c\sqrt{2gH}$, the head, H, then being the height of a column of gas to produce the pressure drop, its density being taken into account.

Since the orifice generally may be designed of such size to produce a small pressure drop, it seems hardly worth while to use the accurate and much more complex formula, especially in view of the uncertainty of the values of the coefficient of discharge under those conditions to which the hydraulic formula does not apply. One general formula is $V=c\times 11.1\sqrt{h\div p\ T}$.

Another formula is: $W=C\times 0.163\ d^2\sqrt{hp\div T}$ in which W=flow in pounds per second, C=coefficient of discharge (average about 0.6), d=diameter of orifice in inches, h=height of column of water in inches equivalent to the pressure drop, p=absolute pressure, pounds per square inch, and T=absolute temperature, deg. F.

3. See (2).
4. See (1).

5. The boiling point of water at atmospheric pressure is 212 deg. F. If one pound of water at a temperature of 212 deg. F., and at atmospheric pressure, be supplied with 970.4 B.t.u. (its latent heat) it will change into steam having a temperature of 212 deg. F. If the pound of steam thus formed is cooled so that 970.4 B.t.u. are taken from it, it will change back into water, or will condense, and the water resulting from the condensation will have a temperature of 212 deg. F. The process of condensation refers only to the change of vapor into liquid and, therefore, the heat of the liquid is not involved. If the liquid resulting from condensation is cooled, the quantity of heat taken from it will just equal the amount supplied in heating it through the same range of temperature, provided there is no loss of heat in either case.

An illustrative example will show how the final temperature of a mixture of steam and water may be secured.

To mix 10 lb. of steam at 15 lb. absolute pressure with 50 lb. of water at 70 deg. F.

From the tables, this steam has a total heat value of 1150.7 B.t.u. per lb. Upon being condensed it will have 1150.7—970.4=180.3 B.t.u.

Water at 70 deg. F. has 38 B.t.u. (total heat above 32 deg. F.) Now, total heat of the 10 lb. of steam=

$$10 \times 180.3 = 1803 \text{ B.t.u.}$$

and total heat of 50 lb. of water=

$$50 \times 38 = 1900$$

Total heat of 60 lb. mixture=3703 B.t.u.

or 62 B.t.u. for one lb. which, according to the table, corresponds to a temperature of about 92 deg. F.

6. The range of working pressures, or the difference between the lowest and highest steam pressures at which the injector will work is dependent upon the injector design as well as the suction head and water temperatures. No practical formula is available to give the relation between these factors.

7. For cold pipe insulation, granulated cork possesses great insulating efficiency, is durable, easy to apply, neat in appearance and is slow burning.

8. Hair felt is preferable to shavings for cold storage insulation.

Transposing Transmission Lines

We are building a transmission line 10 mi. in length; we boost the voltage from 2300 to 6600 and have been advised to "transform" or change the right-hand lead over to the left-hand side every 5 mi. If this should be done, how often? and what is the good to be derived from it? D. L. T.

A. As to the advisability of transposing power transmission wires, actual tests have shown that this is always advisable on telephone lines and where a power and telephone line are adjacent. If not done in this latter case, the phone service will invariably give trouble, due to counter currents being set up in the wires.

In the case of isolated power lines, there are some in operation where transposition is not carried out, and as to the advisability of this, construction engineers differ.

Following its natural law, a current, especially of high potential—flowing through one wire alongside of which is run another, tends to set up a counter current in the second line which opposes any flow which might be sent through it in the reverse direction. This is due to induction, and the resultant current is called an induced current. It invariably throws the weaker surrounding circuits out of balance, although it may not affect its own actual operation.

The spacing of transposition points varies somewhat with conditions, and while your line is only ten miles long, one cross-over in the center will do no harm and may be beneficial. Any adjacent phone or telegraph wires should be transposed much oftener than this, the actual distances being all equal.

Transformer Capacity Calculations

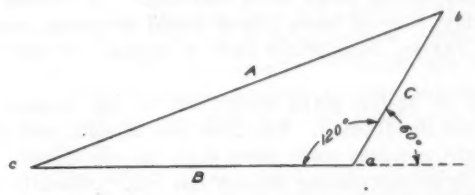
ASSUME three 75-kv.a. single-phase transformers connected delta primary and delta secondary, so as to get both 440 and 220 v., 3-phase secondary. What capacity is available at 220 v. when there is a load of 120 hp. at 440 v.?

A. It can be shown that:

(1) The current in the transformer secondary winding, due to the 220-v. load, is the same numerically as current per phase of the 220-v. load.

(2) The currents in the transformer secondary, due to the separate loads at 220 and 440 v. combine at 60 deg. phase difference, provided the separate loads are of the same power factor.

If, therefore, one load is known, the permissible load at the other voltage can be determined as follows:



VECTOR ANALYSIS OF TRANSFORMER PROBLEM

Referring to the accompanying sketch, A is the total current capacity of secondary winding, or 170 amp., B is the current in winding due to 120 hp. load at 440 v., or 82.5 amp. (taken at 82 per cent apparent efficiency), while C is the load permissible at 220 v.

The angle a is 120 deg.

From law of sines $\frac{A}{B} = \frac{\text{Sin a}}{\text{Sin b}}$. From this the value of C may be obtained, which in this case is 113 amp., or hp., at 220 v., is equal to 82.

In case the two loads are not of the same power factor, the angle a is increased by the amount the two loads differ in angle of lag.

WESTINGHOUSE ELECTRIC & MFG. CO.,
W. R. WOODWARD.

Why Carbon Causes Gas Engine Pounds

Why does carbon deposit in an automobile engine cause a decided pound, accompanied by loss of power? I have seen such carbon deposits burned out and the results were very satisfactory; the pound was gone and the engine's power was greatly increased. J. K.

A. When an appreciable amount of carbon has been

deposited within the combustion chamber of an internal combustion engine, this carbon becomes incandescent and fires the charge when compressed.

It is, therefore, quite evident that the charge contained within the combustion chamber is not always fired at the correct time, and, as a consequence, not only pounding but also a considerable loss of power will result.

The pounding, as you well imagine, is due to the fact that the charge is exploded previous to the piston reaching the end of its stroke, and, as a consequence, the explosion reacts upon the piston, causing the pound and also, incidentally, the loss of power.

Plate Ice Making Questions and Answers

WE PLAN to install a 10 or 15-ton ice plant and wish you to advise us as to the making of raw water plate ice by direct expansion.

Is not the direct expansion method about as good as the brine system and will it not freeze about as quickly as brine?

Please give me the advantages and disadvantages of direct expansion. A. S.

A. Installing a 10 or 15-ton plate ice plant is not advisable. In making plate ice, nothing less than a 50-ton plant should be considered.

Plate ice is frozen from one side only, and it requires from six to eight days to form a plate of standard 11-in. thickness.

The small-sized plates which would be used in a small plant would weigh three tons each. To harvest 12 tons a day, four of these plates would be pulled every 24 hr. The ice tank would have to contain at least 24 plates.

A 10 or 15-ton plant would not be big enough to justify the installation. The first cost is high, and this style plant requires more space than the can plant.

The brine circulating system has been generally accepted as the best for a plate ice plant.

In this system the ammonia evaporating coils are in a separate brine tank. The shell and tube or the double-pipe brine cooler can be used instead of the tank. A pump is used to circulate the cold brine through the coils of the freezing plates and another smaller pump is used to pump warm brine for melting the ice loose from the plates.

In the direct-expansion system, the ammonia is evaporated in the coils of the freezing plates and after the ice has formed to the proper thickness, hot ammonia gas is circulated through the coils to free the ice.

The direct expansion system is complicated and somewhat dangerous, even when handled by an experienced and careful engineer. It is possible to slug the compressor with liquid ammonia and so do damage to the machine or pipe work. The loss of ammonia is always greater with the direct expansion than with the brine circulating system.

For a small plant, the can system is the best, cheapest to install and easiest and most positive to operate. Distilled water plants are in most cases the best in every way; but, if electric current is cheap and the available raw water does not contain matter in solution which will discolor the ice, a can plant using raw water with air agitation will be found very efficient.

Power Plant Engineering contains valuable articles on refrigerating and ice making, as well as articles relating to all other branches of engineering. Publications dealing entirely with refrigeration are: Ice and Refrigeration, published in Chicago; Refrigerating World, published in New York; and Refrigeration, published in Atlanta, Ga. A. G. SOLOMON.

Dense Air Ice Machine Questions

WHAT IS the pressure and temperature of the returning air of a dense air ice machine?

2. What is the temperature of the air leaving the expander?

3. Why is it necessary to compress the air to 210 lb. when only 70 lb. are used on the system?

4. Do you use expansion valves in connection with the cooling coils?

Any information you might give me will be greatly appreciated. M. B.

ANSWERS

THE PRESSURE of the air returning to the machine is practically the same as that discharged from the expander; viz., 65 to 275 lb.

2. The air leaving the expander is practically about at 100 deg. F. below the temperature of the cooling water when no return air cooler is on the machine, or at about 130 deg. F. below the temperature of the cooling water when a return air cooler is employed.

3. The expansion of the air makes it cold. In order to be able to expand the air from 270 lb. pressure to 70 lb. pressure, it must first be compressed from 70 lb. to 270 lb. pressure, and at that pressure be cooled to the temperature of the cooling water, or as much below that temperature as the return air cooler will do.

4. There exists no expansion valve about the machinery, only an expander cylinder with piston and slide valve and expansion slide off valve. The air refrigerated by the expansion in the cylinder passes directly into the refrigerating coils and from the outlet of these into the compressor or into the return air cooler, when the machine is fitted with this apparatus, and from that back into the compressor, while the high-pressure air which also passed through the return air cooler in order to be made colder than the cooling water, passes into the expander cylinder and there is refrigerated to about 130 deg. F. below the temperature of the cooling water, as was said before.

The figures here given are only approximate for usual work, and are varied by the temperatures of cooling water and the temperature of the air returning from the refrigerating coils and by the degree of expansion, which means the pressure difference between the compressed air existing in the expanding cylinder before its entrance is cut off and that emanating from it. The amount of refrigerating work done is in direct proportion to the absolute pressure (that is, gage pressure plus 15 lb) and the going out and the returning temperature. H. B. ROELKER.

Ice-Making Plant Costs

I DESIRE to learn the approximate cost of handling a 15-ton ice plant. Can you give me this information?

READER.

A. The mechanical equipment for a complete plant,

with softener, including everything except building and foundations, would cost about $17,500. This figure includes the insulation for the ice tank which would contain 240 300-lb. cans as well as insulation for a storage room 40 by 19 by 8 ft. high. The building for housing this plant would be 22 ft. 4 in. wide, and 125 ft. 10 in. long, the average height of the walls being about 18 ft. above grade line. GEORGE B. BRIGHT CO.

R. N. COLE.

D.-C. Wiring Calculations

I HAVE a building 1000 ft. from the generator which I want to supply with 50 lamps at 110v., each lamp taking ½ amp. I have 115v. at generator. What size wire or feeders must I run in order to get a drop of 5 v.? In figuring resistance in above circuit, would the return wire be taken into consideration; that is, would the line be 2000 ft. or 1000 ft.? W. C. H.

A. The formula suitable for the calculation of wire sizes, in direct-current work, is the following:

$$A = 21.6\ I\ d \div e$$

Where A is the area, in circular mils;
I is the current in amperes;
d is the length of transmission distance;
e is the permissible voltage drop.

In your particular case we have:

$I = 50 \times \frac{1}{2}$ or 25 amp.
$d = 1000$ ft.
$e = 5$ volts.

Substituting these factors in the above formula, we have:

$A = 21.6 \times 25 \times 1000 \div 5$, or 108,000 circular mils, corresponding to about a No. 0 B. & S. gage copper wire.

Causes of Missing Cylinder

ONE OF THE CYLINDERS, the third, of my gas engine is giving me considerable trouble through continuous failure to fire the charge. What might be the cause of this?

When I hold the terminal within a short distance of the spark plug, I get a good spark.

L. A. E.

A. We are inclined to believe that the trouble which you are having with the missing of the third cylinder of your engine is due to a short circuited spark plug. Under such conditions, the charge could, of course, not be ignited, although if, as you state, the terminal is held a short distance from the binding post of the plug, a spark will appear.

The short circuiting of such a plug may be due to contact points accidentally having been brought together, or, more likely perhaps, to a deposit of carbon and oil between the contacts.

We might suggest that you remove the plug, take it apart, and clean it thoroughly. Then, after reassembling, adjust the contacts so as to bring their ends no further apart than about a thirty-second of an inch.

Wind Power for Electric Generator

IS IT POSSIBLE to operate a farm lighting plant by wind power? Kindly give me your advice on this subject. J. P. S.

A. The difficulty with a farm lighting and power plant, to be operated by a windmill, is the variable amount of power to be derived from the mill. Statistics show that there is some 30 per cent of the time when the wind is not sufficiently strong to drive a mill economically and operate a generator from it, and some 10 per cent when the wind is too high to operate it safely.

For a plant to be operated to furnish current, there must be some means provided for storing electricity in quantities to supply the demand during those times when the mill cannot operate. The only feasible method is the use of a storage battery, which is a rather expensive device.

A good many experiments were tried out on this proposition a number of years ago by Chas. F. Brush, who perfected a system by which the thing can be done, but it has never been found a commercial success because of the high cost of installation of the plant.

Taking into account the cost of installation and the cost of operation and of repairs, it is found that a small gasoline or kerosene engine set, which can be procured now from a number of different makers, is more economical to use than the windmill drive.

Throw of an Eccentric; Valve Travel

SOME AUTHORITIES claim the "throw" of an eccentric to be the distance from the center of the shaft to the center of the eccentric, while others claim it to be twice that distance? Which is correct?

Is the travel of a slide valve measured from the extreme right to the extreme left of its mid travel? If so, is this equal to twice its eccentricity? T. L. H.

A. The distance from the center of the eccentric to the center of the shaft is sometimes referred to as the throw or as the eccentricity. Probably the better of the two is throw, as the eccentric, as you may know, is nothing more or less than a crank shaft with an enlarged crankpin.

The travel of the slide valve is the total distance traversed during one revolution of the eccentric. This is equal to twice the eccentricity of the eccentric.

Proper Electrolyte for Gravity Cells

I HAVE three gravity cells which I have recharged with about 2¼ lb. of copper sulphate. Apparently, however, these cells are inactive and I wish, therefore, to inquire from you as to the probable cause and remedy.

H. S.

A. From your letter we are led to believe that you are not employing the proper electrolyte in connection with your gravity cells, and it is for this reason that these batteries fail to operate. In the case of this type of battery, we find that the two electrodes used are a copper at the bottom and a crowfoot of zinc suspended near the top of the cell.

The copper sulphate solution is used at the bottom of the cell, but is covered, however, with a solution of zinc sulphate, the former being used to cover the copper electrode, while the zinc sulphate is used to cover the zinc electrode. If you will remove about half of your copper sulphate and add the necessary amount of zinc sulphate, we are sure that your battery will operate as it should.

In order to avoid undue evaporation, we would suggest that you cover the electrolyte with a thin layer of some mineral oil.

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Why Americanize?

Events are moving rapidly in the industrial field. Strikes follow strikes. Production falls steadily behind demand. Prices rise and increase the cost of living. Where is the end?

If we, as a nation, are to arrive at a solution of our industrial problems, the great mass of our residents—citizens and non-citizens—must come to a condition of clear thinking as to the relations of men to industry and to our Government.

Wealth—the result of human effort—does not drop from a clear sky; it does not just exist; it must come by work and thought and saving. This must be realized by all workers before we can get industrial co-operation. The more that head work is co-ordinated with hand work, the greater will be the result produced by a given amount of effort. This is true whether the head and hands be those of one person or of many persons.

To get this clearly before all the people involves bringing them to the American point of view—that the Nation is the people, not a thing apart. Some of those high in Governmental circles need education as much as those who form the rank and file of our industrial army. But with them it is a matter of losing sight of a great fact, not a case of lack of understanding.

For those who, coming from an old-world atmosphere, think of government as a thing apart from the people, there is need of Americanization—an understanding of our history, our geography, our methods of government and the responsibilities of the citizen, so that they may realize the community of interest of all the people and of all parts of the country. The greatest danger lies in wrong ideas and the struggle for individual or local immediate selfish advantage on the part of classes and individuals.

A few examples of the experience of others are worth while. "Americanization carried on in our plant has transformed the non-English-speaking workman into an American capable of absorbing shop spirit and enthusiasm."

"With English a closed book, foreigners fail to understand and naturally suspect our American ways. With teaching, they read safety bulletins and standard practice instructions. Reading their new American language is real recreation."

"Opportunity of this kind to learn the history of our country and language has never presented itself before and it is gratifying to note the change in the attitude of the men."

"The most important benefit is that all the men attending the classes are learning American ideals."

These are from four plants where classes have been formed and Americanization tried for at least a year in each case. But the most powerful influence in this work is the helpful attitude of the fellow workers of the foreign born. Those who by birth or long residence have had the chance to know the value of American citizenship and its privileges have a special duty to impart this knowledge to the more recent comers, both that the latter may realize the new life to which they have come, and that our ideals and privileges may not be lost or impaired by misunderstanding action of the un-Americanized.

National Budget Plan

To run any government successfully requires a sound financial policy which should vary only as the will of the people directs. Partisan politics and the pork barrel, which have resulted in sectional development and ill-feeling, are largely the outgrowth of poor business method in the management of our Government. Numerous appropriation bills without any relation to other expenditures have been passed and unjust riders have become laws in order to satisfy the desires of an opposing faction which would otherwise defeat the main bills. No successful business corporation in existence today is run on such slipshod methods as are employed by the Government in its expenditure of billions of dollars. With the question of Government ownership of railroads, telephone and telegraph lines and other public utilities absorbing the attention of the people, there must be shown by the Government a far better system of handling appropriations and raising revenue than has been customary in the past if the confidence of the people is to be placed in their representatives in Congress to take on these additional responsibilities.

It is encouraging to know that our law makers have recognized the evils of the present system and have introduced in the House of Representatives a bill providing for a National Budget Plan, the principles of which should have the support of every voter in the country. It is unquestionably a step in the right direction and the wonder is that the country has been kept out of bankruptcy under the methods that are and have been in use since the formation of the nation. Nothing but comparatively unlimited wealth has saved us.

These principles as set forth by the National Chamber of Commerce, which has for a number of years been advocating the plan, are as follows:

1. That annually, as soon as the close of the fiscal year as is possible, the President shall cause the heads of all departments to submit to him comparative statements showing in detail their expenditures for the fiscal year just closed, appropriations for the year in progress, estimates of expenditures for needs for the year to ensue, and such other information as he may require.

2. Upon receipt of these statements, the President shall have prepared by a special committee organized under his direction a budget which shall show: (A) The condition of the Treasury as shown by current resources and obligations at the end of the fiscal year just closed and for a series of years preceding. (B) The revenues and expenditures of the Government during each of said years. (C) The fixed charges and appropriations and estimated expenditures during the year in progress; and (D) The provisions which, in his opinion, should be made for meeting the revenue and expenditure requirements of the year to ensue.

3. Immediately upon the assembling of Congress in regular session, the President shall transmit to it the budget, accompanied by such letter of transmittal, explanations, analysis and supporting statement as, in his opinion, are desirable in order to get clearly before that body the nature of the proposals contained in it, and the reasons actuating him in their formulation. The President shall in like manner cause the heads of all departments and government establishments to submit to him their statements of supplementary or deficiency appropriations needed by them to meet requirements of their services during the year in progress. These statements shall be examined by the special committee, and the President shall submit them, with such revision as he deems proper, to Congress as Supplementary or Deficiency Budgets for that year.

4. The two Houses of Congress shall amend their rules so as to provide: (A) For a single committee in each House to have jurisdiction over all revenue and expenditure proposals. (B) For the submission of the budget upon its receipt to such committee. (C) For the treatment of the budget as the basis for all revenue and expenditure bills. (D) For the preparation by such committee of a budget bill or bills which shall follow the scheme and classification of the budget as transmitted by the President. (E) For the preparation of a report which shall accompany said budget bill or bills and which shall set forth clearly all features or items in respect to which such bill departs from the proposals contained in the budget with the reasons which have actuated the committee in recommending such changes.

The plan calls for no surrender of power by any department of the Government, but it will give to each member of Congress a comprehensive idea of what funds are asked for, what funds are on hand or can reasonably be expected to come in, and place him in position to judge the relative importance of various expenditures. With this system in use, there would be no need for a plus appropriation for any purpose except in an emergency such as a war.

Now is the time to get back of this movement for a better financial system by expressing your views to your representative in Congress.

Clean Coal

We have only to examine the reports of the Geological Survey to see why coal comes to us with varying percentages of ash and other impurities. Here we will find veins of excellent coal streaked with layers, ranging in thickness from the fraction of an inch to several inches, of bone, slate, shale or sulphur compounds. These impurities result in ash or clinker in the boiler furnace and when the percentage of sulphur is excessive it causes rapid corrosion of all metals coming in contact with the gases of combustion.

While the engineer has always recognized the value of clean coal for his furnaces, it was not until the coal shortage of two years ago that he appreciated the condition in which the coal comes to the mouth of the mine. At that time, many carloads of coal were rejected because of the great percentage of slate and stone which it contained. While the average percentage of unavoidable ash in bituminous coal mined throughout the country is in the neighborhood of 10, many complaints were investigated where the amount of ash was above 30 per cent.

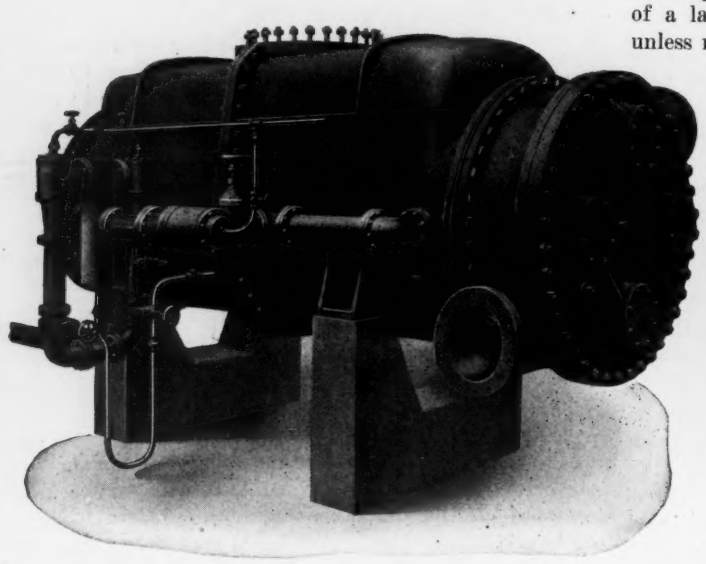
These conditions brought about a more thorough study of coal washing and cleansing processes and today the largest and best equipped mines are prepared to deliver cleaner and better coal than ever before. The

concentrating table method of purification is among the latest developments in the field of coal mining, although it has been used extensively in metal mining. On another page of this issue, Mr. Roberts, who has been intimately associated with the development of this process, describes in detail how it is carried on and the results which are obtained.

Improvement In Air Pump Practice

IN order to insure lower first, installation and maintenance costs, reduce to a minimum steam consumption and power requirements and to improve generally upon existing types of reciprocating vacuum pumps, the Evactor air pump was developed. This pump, although designed primarily for use in connection with all classes of condensing apparatus, is well adapted for service in conjunction with vacuum-producing equipment in general.

It consists of two or more steam ejectors operating in series. Between the steam ejectors is interposed an inter-cooler of either the jet or surface type, depending upon operating conditions.



SURFACE CONDENSER WITH EVACTOR AIR PUMP

The first stage, or primary ejector, is attached directly to the condenser. Steam at boiler pressure is admitted to the jets contained in this ejector, the construction of which is such that air and noncondensible vapors are withdrawn from the condenser, compressed in volume and discharged into the inter-cooler. A small quantity of water is admitted into the inter-cooler, condensing the steam used by the primary ejector, cooling the air and noncondensible vapors, thereby reducing their volume.

Air and noncondensible vapors are removed from the inter-cooler and discharged to atmosphere by means of one or more secondary ejectors especially designed for that service.

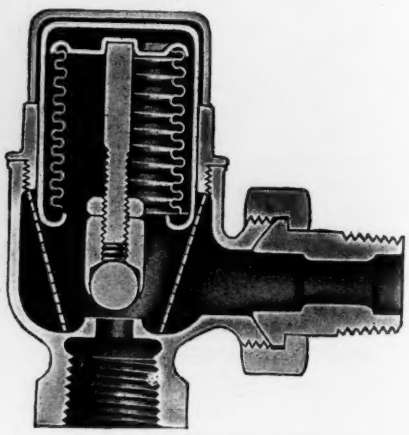
If the water used in the inter-cooler is of suitable character, it can be readily utilized as make-up boiler feed water. In such case the jet type of inter-cooler can be used. If the water is contaminated or salty, a surface inter-cooler is used so that the condensation can be recovered for the boiler feed system.

Steam discharged from the secondary ejector can be readily utilized in heating the feed water or for any other purpose where low pressure exhaust steam is desirable.

The Evactor air pump has three capacities—a normal capacity at which it is most efficient and at which capacity it usually can be operated—another capacity of about one-third less than normal, and still another capacity about one-third greater than normal, thus practically corresponding to three pumps in one, and permitting operation with a minimum steam consumption under variable conditions.

A New Expansion Radiator Trap

STEAM heating radiators, especially when located a considerable distance from the boiler, should be trapped. The condensate, which in a small heating plant may be returned to the boiler through the steam pipe without serious detriment, would in the case of a large plant be sufficient to cause water hammer unless removed at the radiator.



SECTION THROUGH NEW RADIATOR TRAP

There are various traps available for this purpose, one of the newest of which is shown in the illustrations. It consists essentially of a spirally corrugated tube comparatively large in diameter, closed at one end by a solid head. The other end is so attached to the body of the valve, inside of which it is contained, as to divide the body into two chambers. The space between the expanding unit and the body, or the expansion chamber, is filled with a volatile liquid.

The valve stem is fastened at one end to the expansion tube head, while the other end carries a socket containing the bronze ball valve head. This ball is free to revolve, so that it may not seat in the same position every time and become worn out of shape. A conical strainer is fitted, having a free area 10 times that of the valve opening. When the heating system is not in use the valve is in the position shown herewith. When steam enters from the right it comes in contact with the inside of the tube, heating the tube and the volatile liquid, causing the latter to expand and move the valve downward to its seat.

When sufficient condensate has gathered in the valve to cool off the tube, the volatile liquid contracts sufficiently to allow the valve to open and the steam to force out the condensate. The steam then causes the valve to close, repeating the cycle as often as the amount of condensate demands.

This trap is made to work on any degree of vacuum, or steam pressures to 20-lb. pressure.

An Efficient Superheater

DEMANDS for increased efficiency in the power plant have reached the point where it is not sufficient that manufacturers be able to supply efficient machinery and boilers to the new plant, but they must also be prepared to furnish suitable equipment for reducing the cost of operation of old plants.

This saving in cost of operation may, in the case of a steam boiler, be achieved either by a saving in the actual amount of fuel burned, or by a partial recovery of the heat which would ordinarily go up the stack. Among the apparatus designed for the recovery of heat in connection with either old or new plants is the superheater shown in the accompanying illustrations.

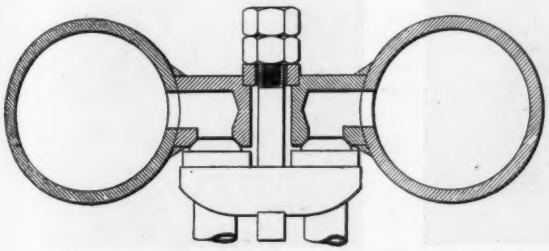


FIG. 1. BALL JOINT CONNECTION BETWEEN UNITS AND HEADER

This superheater includes many good points in its design, one being solid steel construction throughout. The units, which are of a small size of solid drawn steel tubing, are connected to the header by means of a ball and socket joint, as shown in Fig. 1, which eliminates strain on these joints, thus guarding against leakage.

The large number of small tubes present to the hot gases considerable more heating surface, with less resistance to the passage of the gases, than would be possible with fewer tubes of a larger size. The fact that these tubes are of seamless drawn steel tubing is a further advantage, in that the smooth surface of the tubing is not likely to gather soot.

The great flexibility of design possible in this type of superheater renders it adaptable to all kinds of boilers and conditions. In installing this superheater in all types of boilers, it is located in such a position that the gases, after leaving the superheater, will deliver further heat to the boiler tubes; thus more heat is absorbed by the superheater than would be the case if placed in the relatively cold gases nearer the uptake. Furthermore, the headers and connections are placed in such a position that they may be inspected at any time without entering the boiler, thus assuring that they be always in the best of condition and accessible in the case of failure of any of the units. A typical installation is shown in Fig. 2.

Mica Insulated Armature Coils for Generators

FAILURE of armature coil insulation is the most common single cause for generator shut-downs, which are invariably expensive, either through loss of revenue, or repair charges, or both.

A perfect insulation—one that never fails—is, at present at least, unknown.

By a happy choice, electrical engineers decided more than 20 yr. ago on mica as the best available material, and are now finding mica a solution for some of the problems of the large capacity, high voltage and high speed designs demanded by the up-to-date power plant.

Mica is a first-class dielectric. Its insulation resistance increases with temperature, a valuable characteristic for higher temperature work, and in direct contrast with the properties of treated tapes, in which the insulation resistance and loss increases rapidly at temperatures above 100 deg. F.

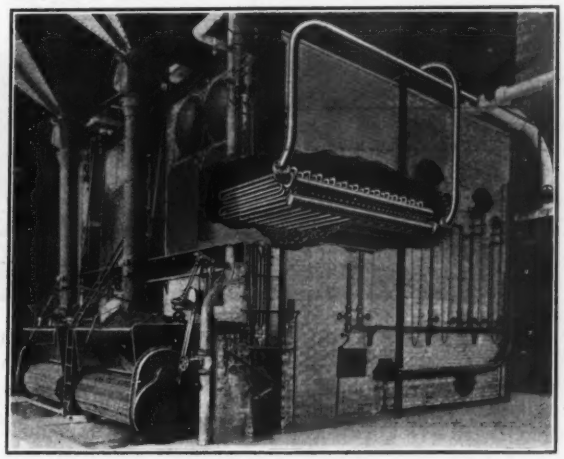


FIG. 2. A TYPICAL SUPERHEATER INSTALLATION

It is unaffected by temperatures far in excess of those encountered in the modern, well-ventilated alternator. It is impervious to the static discharges present in all high voltage machines, and it is resilient and retains its resiliency indefinitely—thus helping to hold the coil tightly in place.

Mica is a mineral obtained in the form of large crystals. These split readily into thin laminations or flakes. The flakes are pasted uniformly on cloth or paper to facilitate handling and to provide a mechanical support during application.

In the form of a "wrapper," that is, pasted on large sheets of specially treated paper, mica is used on alternating-current generators on the straight sides of each armature coil, to provide insulation between conductor and iron, the operating voltage of the machine determining the number of turns, or the thickness of this insulation wall.

All known insulating materials are relatively poor heat conductors. This is equally true of mica and treated tapes. Therefore, the tighter and the thinner the wall, the better the heat radiating characteristics of the

coil. For the lower voltage machine the mica wrapper is applied as tightly as is possible by hand, while for the higher voltage windings, in general 6600 v. above, where the insulation wall must be relatively thick, special patented machines are used which apply the wrapper under heat and pressure, and finish it to a solid, compact wall.

In general, all of the larger capacity generators have relatively wide cores. Internal "hot spot" temperatures, considerably higher than those measurable by thermometer, exist. On all such machines, each conductor of the coil is also insulated with mica tape, and in many cases each individual strand or wire of the conductor as well.

Concrete Coating for Steel Stack

WHEN one of the stacks of the Cleveland Electric Illuminating Co. began to show signs of age, it was decided, rather than to replace it with a new steel stack, to give it a coat of concrete while it was in continuous service. This required unusual methods, as the stack was 214 ft. high and had a diameter of 40 ft. at the base and 19 ft. at the top. A wooden tower 256 ft. in height was built to contain the concrete conveyor. The concrete, says Successful Methods, was placed in the forms by means of chutes which reached from the tower, halfway around the stack, sections of the chute being removed as the forms were filled. The working scaffold was hung from a cat head.

The total volume of cement was about 140 cu. yd., the thickness ranging from 9 in. at the base to 5 in. at the top. Reinforcing of ⅝-in. rods and wire mesh was used. Part of the work being done in winter time necessitated heating the aggregates before mixing by placing live steam pipes in the piles. The concrete was protected while setting by a heavy tarpaulin wrapped around the stack.

The work was done in less than five months at a considerable saving in time and money on the cost of a new steel stack.

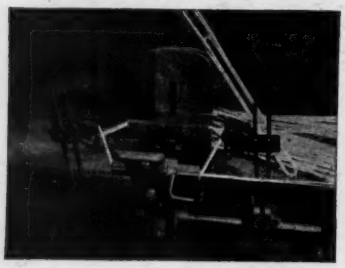


FIG. 1. PULLING MACHINE USED TO FORM ARMATURE FOR ALTERNATING CURRENT GENERATORS

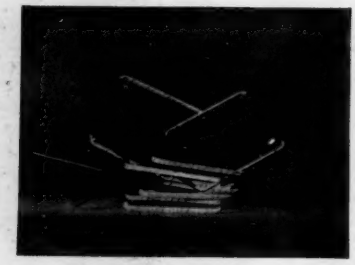


FIG. 2. ARMATURE COILS AFTER IMPREGNATION AND WITH HAND APPLIED TAPED WRAPPER

FIG. 3. MICA WOUND ARMATURE COILS AS USED ON ALTERNATING CURRENT GENERATORS

Service to America

"IT IS the primary ambition of the American Red Cross to be of service to Americans," said Dr. Livingston Farrand after announcing the peace program of the Red Cross in a recent address.

"First on the peace program for America is nation-wide activity for the promotion of public health and hand-in-hand with this crusade will go a vigorous campaign for the extension of the country's nursing resources; the broadening of Red Cross Home Service that in the war proved so helpful through the assistance it was able to give the families of soldiers and sailors, and which is to be of general usefulness where other social agencies are lacking; greatly increased Junior Red Cross activities; extension of Red Cross facilities for emergency disaster relief; completion of relief measures for the victims of the war in this country and overseas, and preparation to fulfill whatever duties may be laid upon it as the official volunteer relief society authorized to assist the Army and Navy.

"The Red Cross authorities realize that the astonishing generosity of the American people during the war and the present high cost of living at home might legitimately lead many to expect a release from further demands for assistance to other peoples," continued Dr. Farrand, "but we must remember that our Allies were much harder hit by the war than we were and that we have incurred obligations to them which honor demands shall be discharged. In naming the sum of $15,000,000 for the campaign, the Red Cross tried to determine the smallest amount which will enable it to round out its work and make effective the donation of army goods rather than to estimate the generosity of the American people. Large, vigorous chapters are necessary to carry on the work. For this reason the enrollment of members is the chief purpose of the November campaign."

New Japanese Power Plant

Two 25,000-kw. steam-driven turbine units, which, when installed, will complete the largest steam-driven electrical installation in the Far East, are now being erected at Osaka, Japan, for the Osaka Electric Light Co.

Located in an extensive industrial district, this company furnishes light and power to street railways, steel works, ship builders, copper refining plants, paper mills, electro-chemical installations and other industries.

It is noteworthy that in 1908 the Osaka Co. installed three steam turbine units of 3000 kw. each. In 1910 two more units of like capacity were added, and in 1911 two 500-kw. units. The 25,000-kw. units now being installed will bring the capacity of this plant up to 100,000 hp.

The Vicious Postal Zone Law

By Senator Arthur Capper, of Kansas.

IT HAS been argued that the postal zone increases apply only to the advertising sections of magazines. This is perfectly true as a statement of the mere words of the postal zone law.

It is not true as a statement of facts.

For a periodical or a newspaper is a unit from cover to cover. It is one unit of bulk that is never broken. The argument that the increased postage merely affects advertising is virtually the same as if it were argued that the postal zone legislation had provided that the upper half of a magazine should pay postal zone rates and the lower half flat rates. It would be a mere bookkeeping separation that would not in the least affect the postage cost to the reader, for the reader—who is the ultimate consumer—takes the magazine as it comes, and the cost of the magazine is its cost as a unit, and its postage cost to him is its entire cost as a unit, no matter how ingeniously or intricately one may subdivide the component parts.

There is one other important factor, also, which I feel many sincere and ordinarily keen-minded citizens have overlooked, and that is, that the magazine and newspaper differ from every other commodity—if you wish to consider newspapers and magazines as merely commodities—in the fact that it is the only "commodity" that is sold to the consumer at less than its actual cost of manufacture!

And a newspaper or magazine is the only "commodity" of which this is true.

You cannot buy the blank paper that is used in a single copy at the mill for the price at which the entire copy is sold to you, with the additional expenses added of its printing, illustrations and with the works of the ablest and highest paid writers in its columns! This would not be possible without the advertising pages, as will readily be appreciated. So that the benefit of the less-than-cost-of-manufacturing price of the magazine goes to the reader not only in a pecuniary saving, but in its social, cultural and civic advantages.

Should we, as patriotic, clear-thinking citizens, do anything to make difficult the accessibility of our newspapers and periodicals?

I think as a matter of fundamental principles we should not. I am the more confirmed in this view when I see that the United States is one of the greatest reading nations in the world, that it has a national periodical press that has been one of the greatest factors in unifying its idealism from the Atlantic to the Pacific in the greatest emergency our nation ever faced. We have only to think of such countries as China and Russia or a half-dozen other non-periodical and non-newspaper consuming nations to give us food for very serious thought in this matter of legislating repressively against the easy accessibility and wide circulation of one of the greatest educational instruments of modern civilization.

Now as to the advertising and whether it should pay a higher rate than the body of the magazine. I think I have answered half of that question when I point out that the periodical and newspaper is the only product that is sold for less than its cost of manufacture, and that this fact is made possible by the advertising. Advertising is nothing but a bulletin board—the bulletin board of our economic, wealth-producing, business life.

The difference between advertising and an ordinary economic commodity is, to my mind, this: that advertising is an idea, the germ of an idea, a thought; it is the economic, generating germ of infinite wealth-producing potential; it is, in itself, not wealth production, but it means the production of wealth by reaching possible consumers who otherwise would have been deaf, dumb and blind in their demands upon our national wealth production. What the cultural, educational and stimulative reading pages are to the social and civic factors in our national life, just that is what advertising is to the economic and wealth-producing side of our nation. Both the editorial and the advertising pages are nothing but thoughts; they are the stimulations, the stimulative germs of an enormous creative potential in all channels of our civic and economic life. To me it is unsound policy that would attempt to limit or restrict the circulation of stimulative thought throughout our nation on the ground of postal cost.

The most unfortunate part of this postal zone legislation is that it is an insidious and dangerous attempt to set back postal history 70 yr. and re-establish the universally condemned principle of postal cost determining the postal rates. It abolishes the sound postal principle of equal postage to all parts of our nation. The rural free delivery—one of the most vital and important postal functions—is conducted at almost a total loss, and if this vicious and unsound cost principle is once established, the demoralization of our splendid postal principles is only a matter of logic and time.

News Notes

At the 38th convention of the Association of Edison Illuminating Companies, at New London, Conn., the election of officers for the ensuing year resulted in a choice of the following: President, W. H. Johnson, vice-president Philadelphia Electric Co., Philadelphia, Pa.; vice-president, M. S. Sloane, Brooklyn, N. Y.; secretary, Percy Miller, New York, N. Y., and treasurer, Ernest A. Edkins, Chicago, Ill.

Executive committee consists of Chas. L. Edgar, Boston, Mass.; W. W. Freeman, Cincinnati, Ohio; Samuel Insull, Chicago, Ill.; John W. Leib, New York, N. Y.; Joseph B. McCall, Philadelphia, Pa., and the president, vice-president, secretary and treasurer, ex-officio.

L. G. Chase, formerly efficiency engineer, Rosemary Manufacturing Co., has recently been appointed mechanical engineer of Yarnall-Waring Co.

On Oct. 1, the Chicago Pneumatic Tool Co. will remove its Birmingham office from 801 Brown Marx Building to 1925 Fifth Avenue, North.

The Sanford Riley Stoker Co. announces the appointment of M. G. Brennan as district engineer in the Western territory and W. Mather as district engineer in the East.

On Sept. 8 the business of the Van Wie Pump Co. of Syracuse, N. Y., was sold to the East Iron & Machine Co. of Lima, O. This business was established in

1860 in Baldwinsville, N. Y., as White, Clark & Co., later was changed to the Baldwinsville Centrifugal Pump Co., and in 1905 was incorporated as the Van Wie Pump Co. The sale includes all drawings, patterns and parts as well as the good-will, and repairs of apparatus heretofore made by the Van Wie Co., as well as new apparatus will be furnished by the East Iron & Machine Co.

FRANKLIN W. GILMAN, combustion engineer with the Sanford Riley Stoker Co., of Worcester, and the Murphy Iron Works, of Detroit, who sailed from Vancouver on Oct. 2 for Japan, will remain in that country for about a year in connection with the installation and operation of stokers manufactured by the two companies.

AN IMPORTANT development of Thermit welding in American shipyards is anticipated by the recent approval by the American Bureau of Shipping of the Thermit process for welding stern frames, rudder frames and other heavy sections on ships registered under their classification. The only qualification is that this Bureau be notified sufficiently in advance to have a surveyor in attendance during the welding operation as well as to inspect and test the weld when completed.

While the Thermit process has been used since 1903 for making marine repairs and has a great many successful welds of this nature to its credit, the process was never officially approved by the American Bureau of Shipping and most of the repairs were made on vessels not classed by them. It is due entirely to the unbroken record of successful marine welds that the Bureau now accords its official sanction to the process.

NEW YORK SUN copyright cable states that S. C. Davidson, of Sirocco Engineering Works, England, has invented apparatus to cheapen and expedite the manufacture of rubber, by converting latex into rubber within 24 hr., instead of two weeks, as at present. It is estimated that this process, if practicable on a large scale, will revolutionize the rubber industry.

Book Reviews

PRACTICAL MATHEMATICS FOR HOME STUDY, by Claude Irwin Palmer; 492 pages, 5 by 8 in., green cloth, flexible; first edition, New York, 1919; price, $3.

This volume is a condensation of an earlier four-volume work by the same author. It covers the same subjects in a more abbreviated form, except that a few new topics have been added.

Part I is devoted to the elements of arithemtic, starting with a review of the simplest forms and progressing through those more advanced. The numerous practice examples at the end of each chapter are, wherever possible, based on some practical use. Part II covers geometry, chapters being devoted to plane surfaces, lines and angles, triangles, circles, etc. Many of the examples, as in Part I, are based on practical uses. Part III treats only of such algebra as the practical man has use for, in addition to a chapter on graphic charts. Part IV expounds the use of logarithms, trigonometric functions, and the solution of triangles. Twenty pages of tables conclude the volume.

The book is written in a very lucid manner, the numerous engravings are clear, the type matter good, and by no means least, the book opens flat. To the man of limited education who desires to improve his knowledge of mathematics, this book will prove valuable.

BOILER FEED WATER, by Percy G. Jackson, 102 pages; first edition 1919, Philadelphia, Pa.; cloth; price, $2.00.

If it were possible to list all the boilers of the country that are in need of feed water treatment, a keen realization would be afforded of the necessity for more attention being paid to this subject.

This little book by Mr. Jackson is a creditable attempt to bring to the attention of the superintendent as well as the engineer this important side of power plant operation. No attempt is made to explain in theory the action of the various undesirable constituents of the feed water on the boiler, but rather to point out the dangers resulting from neglect or ignorance, and to explain the various methods of eliminating them.

The author's experience as chemist in the practical handling of boiler feed water problems makes this book particularly authoritative.

MATHEMATICS FOR ENGINEERS, Part I, by W. N. Rose; 510 pages, cloth; New York, 1919.

In writing this book the author has assumed a knowledge, on the part of the reader, of arithmetic and algebraic addition, subtraction, multiplication and division. He then goes on to more advanced algebra and plane trigonometry. There are chapters devoted to graphs and graphic charts, alinement charts for solving various problems, computation of areas of irregular curved figures, calculation of earthwork volumes, and the determination of laws. The last chaper is devoted to higher algebra, serving as an introduction to Part II, which is published in a separate volume.

In general, the arrangement of the matter is good, being graded from the easier subjects at the front of the book to those more difficult at the back, and the method of presenting, results in clearness. It is particularly suited to the student of engineering.

STEAM TURBINES, a Practical and Theoretical Treatise for Engineers and Students, by J. A. Moyer, 496 pages, cloth; fourth edition, 1919; New York; price, $4.

Development of the steam turbine is mainly along the lines of increase in the methods of application and in size. In this book, therefore, the fourth edition of Mr. Moyer's work, the chief points of difference from previous editions are manifested in particular by the changes in the chapters on the low-pressure turbine and the reaction turbine, as well as new applications of the other types.

The author's purpose in this book was to strike a happy medium in a combination of the theoretical and practical, so as to appeal to the student as well as the practicing engineer. Therefore, besides the chapters on design, there are a number describing the various commercial types and their application, as well as methods of testing.

The last two chapters cover "Gas Turbines" and "Electric Generators for Turbines." The book ends with an appendix of some 60 practical exercises.

THE APPLICATION of spray nozzles for all industrial purposes, also engineer data involved in the installation and use of spray nozzles, are dealt with in Bulletin No. 5, recently issued by the Star Brass Works of Chicago.